Materials & Methods

Selection & use of

metals, nonmetallics, parts, finishes,

in product design & manufacture

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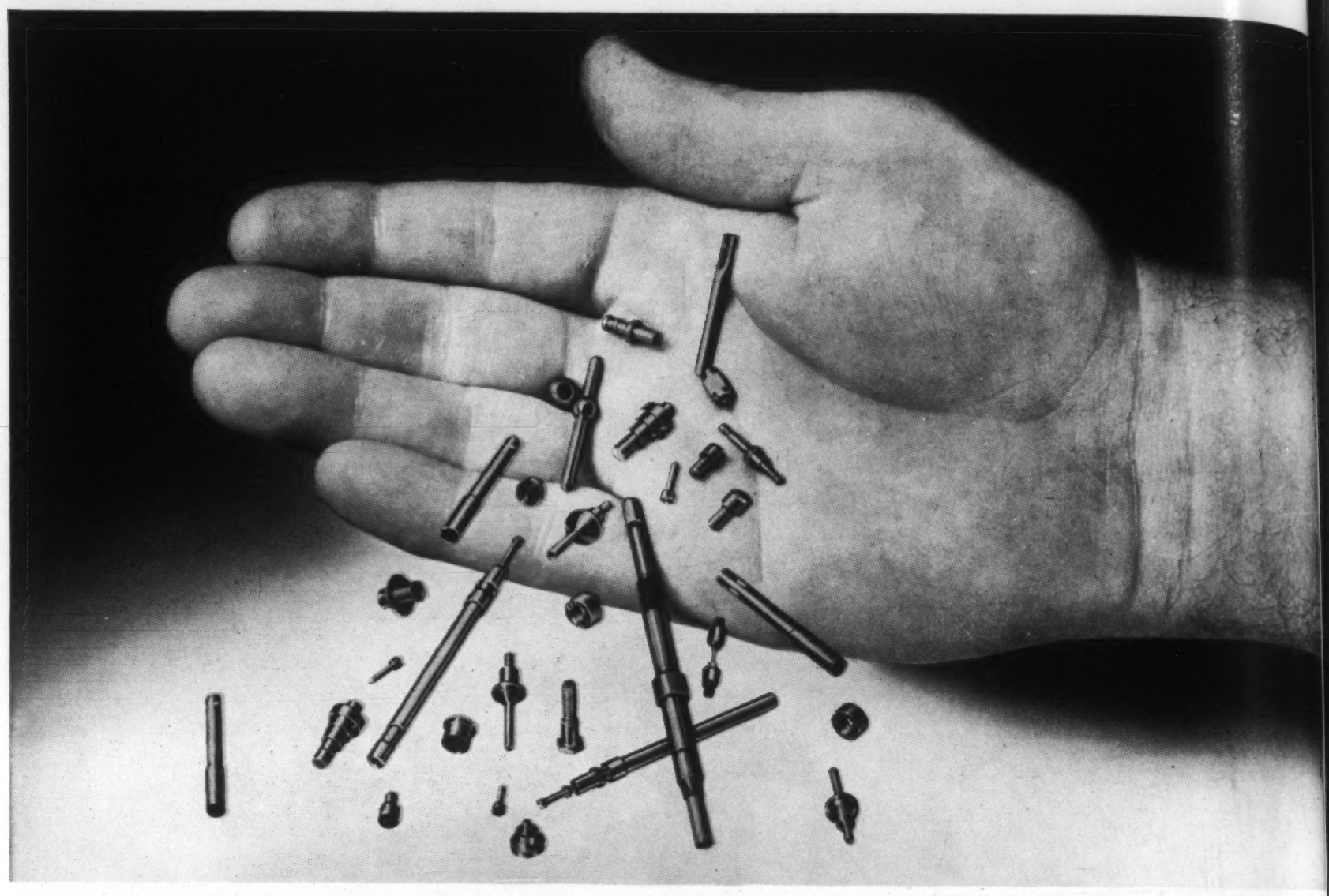
OTHER FEATURES:

HOW PLASTICS PIPE STACKS UP

TRANSPARENT CONDUCTIVE COATINGS

NEW SHAPES FROM OLD RAILS



Do small parts like these give you large problems?

Anaconda Rod solved costly production problems for G & F Manufacturing Company, Philadelphia

The trend toward miniatures has led to a tremendous increase in the use of small precision parts like these. And this has placed a heavier burden on the screw machine operator and the buyer of rod. Uniformity of alloy and dimension in batch after batch of screw machine rod is vital for economical production.

ONE COMPANY'S PROBLEM: The G & F Manufacturing Company of Philadelphia specializes in automatic screw machine production of minute parts, finished to precise dimensions. This company was experiencing costly production delays with the rod they were using, due to jamming and freezing of the rod as it was fed into the machines.

THE SOLUTION: Then G & F tried Anaconda Free Cutting Brass-271 Rod in the diameters required for their type of small-part production. They found it highly satisfactory. Down time, due to jamming or freezing of the rods, has been practically eliminated and production schedules are completed without costly interruption.

Whether for small parts of extreme accuracy—or for ordinary screw machine production—The American Brass Company can furnish free-cutting copper and copper-alloy rods fabricated to meet the requirements of the operation—uniform in length, diameter, temper and composition.

FREE TECHNICAL SERVICE: It is the function of the Technical Department of The American Brass Company to assist metal users in the solution of special problems. This service is at your disposal without charge or obligation.

Comprehensive data on composition and machinability of standard Anaconda Alloys, standard specifications, weights and dimensions of standard rods is available in Publication B-3. For this booklet—for special technical assistance—write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 5662

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Selection & use of

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AUGUST 1956 **VOL. 44, NO. 2**

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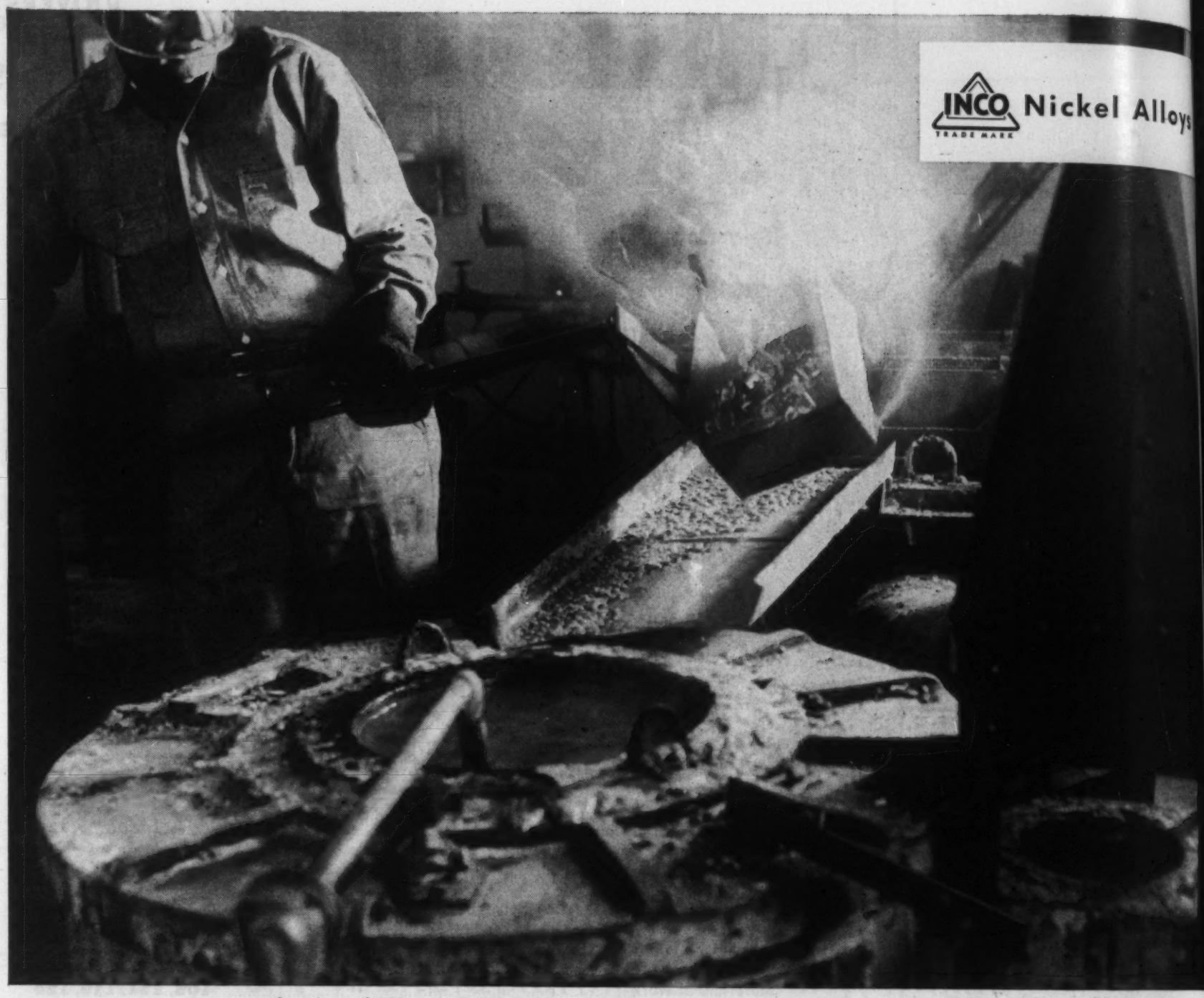

In wrought Inconel "Neu-pot", KLK Manufacturing Company, Logansport, Indiana, treats small parts faster. For information about the "Neu-pot" write Rolock, Inc., Fairfield, Connecticut.

Treated in wrought Inconel pots, these small parts cost less

volume goes up, pot replacement down

These parts are done to a turn . . . in nice time, at low cost.

That's because the salt bath is contained in a Rolock "Neu-pot" made of wrought Inconel* nickel-chromium alloy.

KLK Manufacturing Company reported that unlike most "pot" materials, Inconel alloy retains original heat transfer characteristics throughout its useful service life. With it, loads can be hurried along as rapidly as good practice permits. Volume goes up, cost per piece down.

Long pot life lowers cost, too

In this installation, KLK goes on to say, Inconel nickel-chromium alloy also substantially increases pot life. They report that former pots gave, at best, only six weeks service. Their first Inconel "Neu-pot" lasted almost 5 times longer.

In overall pot expense KLK saves 50 percent by using wrought Inconel alloy. The company also realizes a major reduction in down-time. Both savings are reflected in the cost per piece.

Is high sustained heat, or heat plus severe corrosive conditions your problem? If so, look into Inconel. Write for the Inco booklet, "Keep Operating Costs Down As Temperatures Go Up."

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Inconel... *for long life at high temperatures*

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Materials Outlook

VACUUM FORMING SHEET WITH A POLYESTER FINISH is being made on a developmental scale by laminating Mylar film to extruded high impact polystyrene. The toughness and the resistance to scratching, abrasion and chemicals, as well as the high luster of the Mylar film give polystyrene a durable and attractive finish.

ELECTROLESS NICKEL PLATING has been successfully applied to iron powder parts and to aluminum castings. This nonelectrolytic process, which produces uniform, nonporous nickel-phosphorus coatings, looks particularly promising for aluminum die castings — not only where decorative electroplates are desired but also for the purpose of improving the physical properties of the castings. Bright coatings can be deposited if required.

NEW PERMANENT MAGNET MATERIALS, consisting of high purity manganese-bismuth compounds, have at least ten times the resistance to demagnetization of most commercial magnets now available. Their high coercive force should make them particularly suitable for equipment that might otherwise be adversely affected by external magnetic field. Since the material is in powder form, magnets are made by imbedding the particles in a plastic binder. They can be made in any desired shape and are nonconducting, since the binder acts as an insulator.

A BLACK NYLON FIBER with high resistance to ultraviolet degradation has been developed. It is available in 200 denier, 34 filament form and is priced at $1.80 per lb.

A TARNISH RESISTANT SILVER-LIKE COATING is provided by a new electroplating process. The copper-tin alloy plate, which is deep white and resembles polished silver, is produced in a cyanide bath with a pure copper anode and current densities up to 140 amp per sq ft. The coating is claimed to have greater hardness and abrasion resistance than nickel plate.

MOLYBDENUM DEVELOPMENTS: 1) Molybdenum-base alloys said to have greater useful strength above 1600 F than any existing commercial materials are currently available. Three of the arc-cast alloys, containing 0.3 columbium, 0.5 titanium and 1.0% vanadium, respectively, have better strength than unalloyed molybdenum. Another, with 2.0% tungsten, has better weldability. 2) Work on coatings for protecting molybdenum against high temperature oxidation seems to point to nickel-chromium combinations for temperatures up to 2000 F. Both electroplated chromium-plus-nickel layers and sprayed nickel-chromium alloys containing silicon and boron have been effective, although performance of coated

Materials Outlook

turbine blades has not yet been checked in engine tests. Only complex sprayed coatings and ceramic type coatings appear suitable for temperatures above 2000 F.

A STABLE POLISHED SURFACE ON PURE ZINC can be obtained with a new chemical polishing bath. Polishing solution consists of nitric acid, ethyl alcohol and hydrogen peroxide, and about 2 min immersion at room temperature is required to produce highest luster. The resulting polished surface resists rapid oxidation up to approximately 660 F in air or in a sodium-potassium nitrate salt bath.

FLAME RETARDANCY OF CELLULOSIC FIBERS can be improved with a new compound, titanium dichloride diacetate, which should be in pilot production shortly.

A STRONG, HIGH DAMPING ALLOY, consisting of nickel, cobalt and five additional but undisclosed elements, has been developed for use in turbine blades. Its ultimate tensile strength at 1200 F is about 100,000 psi — five times that of 12% chromium steel. Its damping capacity at this temperature is nearly equal to that of chromium steel at 900 F.

SOFT SOLDERS WITH BETTER HOT STRENGTH can be obtained by adding various alloying elements to conventional tin-lead compositions. Additions of cerium, nickel, manganese, germanium and tellurium improve 70 tin-30% lead solder. Additions of cerium, nickel and germanium improved 30 tin-70% lead solder.

WORLD CAPACITY FOR PRODUCING MAN-MADE FIBERS is expected to reach 7,874,000,000 lb by 1957.

HARDER, STRONGER BRASS POWDER PARTS are being obtained with new brass powders that contain nickel and phosphorus and, in some cases, iron. Physical properties are said to approach those of wrought brass parts.

A FLAME SPRAYED BORIDE BASE COATING can protect irons, mild steels and stainless steels against attack by molten aluminum. The coating has excellent oxidation resistance up to 1800 F and a life of 1200 hr in the 1500-1550 F range. Such a coating may make possible a reduction in the cost of aluminum die castings.

AN EXCELLENT CONDUCTOR WITH GOOD HOT STRENGTH has been achieved with the development of a copper-zirconium alloy. Electrical conductivity of the alloy is 95.8% of the copper standard, and its 100 and 500-hr rupture strengths at 550 F appear to be in the 32,000-41,000 psi range. The material is slated for use in electric motor commutators subject to temperatures above 500 F.

Materials BRIEFS

rop Forging?

on used for swords during an- ent German times was processed a novel technique. Iron chips re fed to turkeys, then recov- ed at the other end, and forged to a sword blade.

arroom Melody

lass crystal bowls are used to rm a unique musical instru- ent. The hemispherical glasses e arranged in series and played touching the edges with a mp finger.

queezable, Too

olyethylene is being used as an ntment base for a number of edicinal products. The base is ot affected by temperature anges and remains soft and sy to spread.

What Color?

aint products consumed by cars nd trucks built last year totaled 5 million gallons. This quantity ould make a 22-acre lake 7 ft in epth.

Aluminum Crowns

uminum caps, used to protect a ooth under repair, are being im- act extruded from 0.005-in. alu- minum foil. These temporary aps are available in 20 sizes.

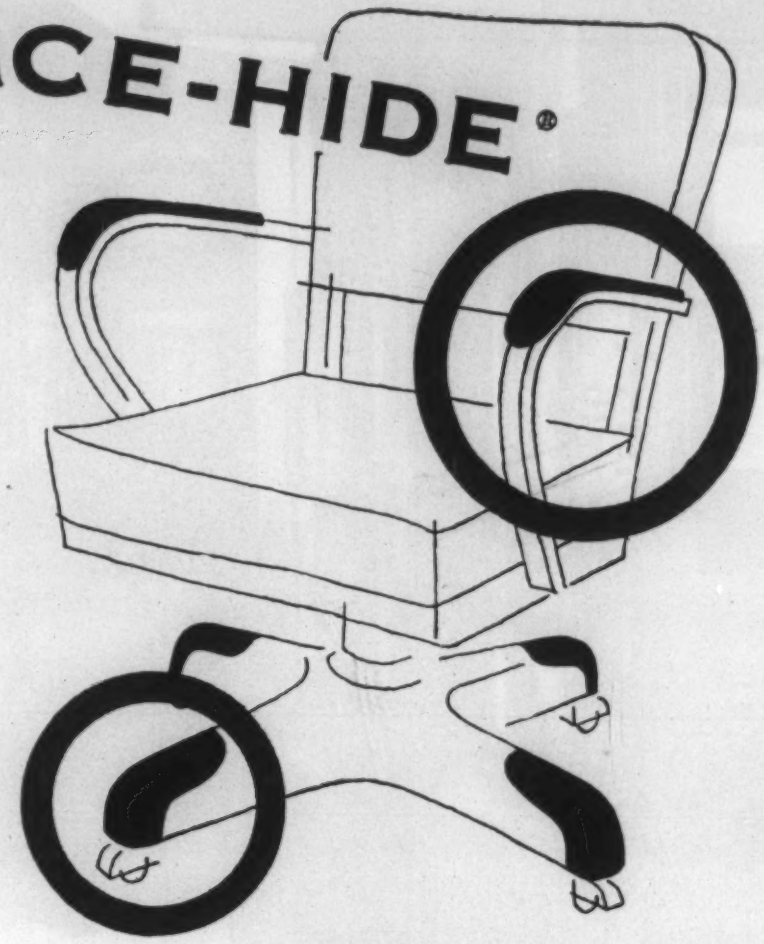
There's a Rub

Miniature reproductions of en- graved monumental brasses can retain the fine details of the orig- inal. The old art of brass rubbing forms the basis of the reproduc- tion technique.

Alchemy

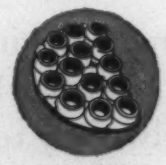
Electrical steel can be rolled so thin that a stack of 8000 sheets stands no higher than an inch. It is 20 times thinner than a human hair and, by weight, is literally worth more than gold.

ACE-HIDE®

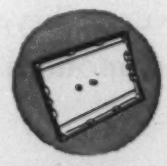


the new molding material that's both **TOUGH** *and* **GENTLE**

Ace-Hide acid pail



Molded top for golf bag



Large molding is lid for beverage cooler

Ace-Hide is a new rubber-plastic molding material designed to take a beating without showing it. Its toughness, smoothness, resilience and excellent chemical resistance have already led to wide-spread use for things like chair arm pads, scuff guards, acid pails and golf bag tops.

Ace-Hide is a special blend of rubber with plastic, hence is light in weight and has good electrical and thermal insulating properties. Rigidity and impact strength (to 10.0 Izod) can be varied to suit. Takes inserts well. Surface is smooth, shiny. Does not develop flexing cracks, and ages well. Ace molding facilities offer wide range of sizes and shapes. We'll be glad to make specific recommendations. Write today.

Ace-Hide and many other hard and soft rubber, plastics, and rubber-plastic blends are described in 80 pg. ACE Handbook. Write for your copy today!

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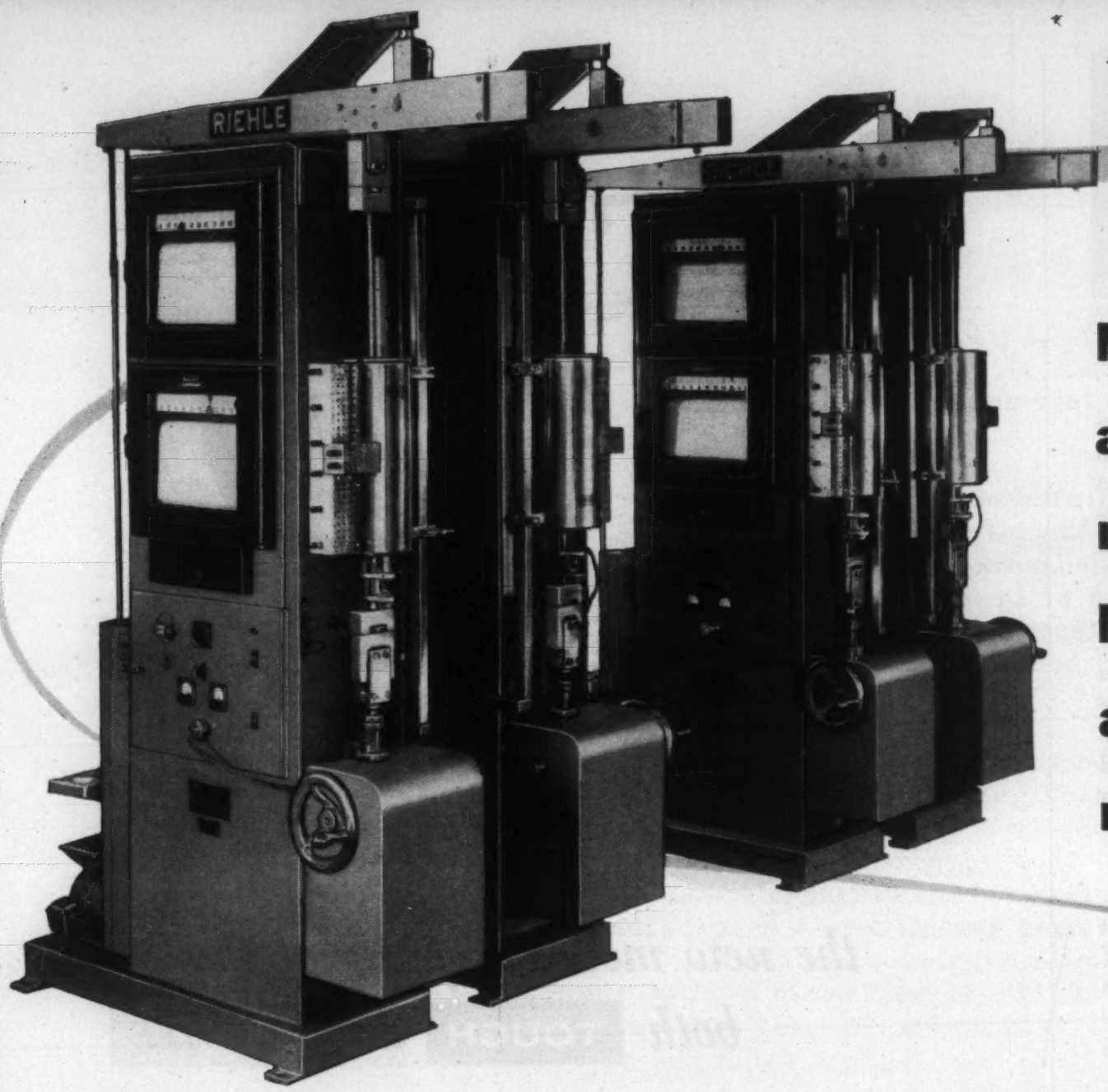

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Men of Materials...

Richard B. Greene is coordinator for plastics and resins in the Barrett Div. of Allied Chemical & Dye Corp. Dr. Greene was employed by the Barrett Div. after graduating from Pennsylvania State University in 1940. He has been associated with Barrett's resin program since its inception in 1948. He holds a B.S. from Purdue, an M.S. from Illinois and a Ph.D. from Penn State.

Greene says:

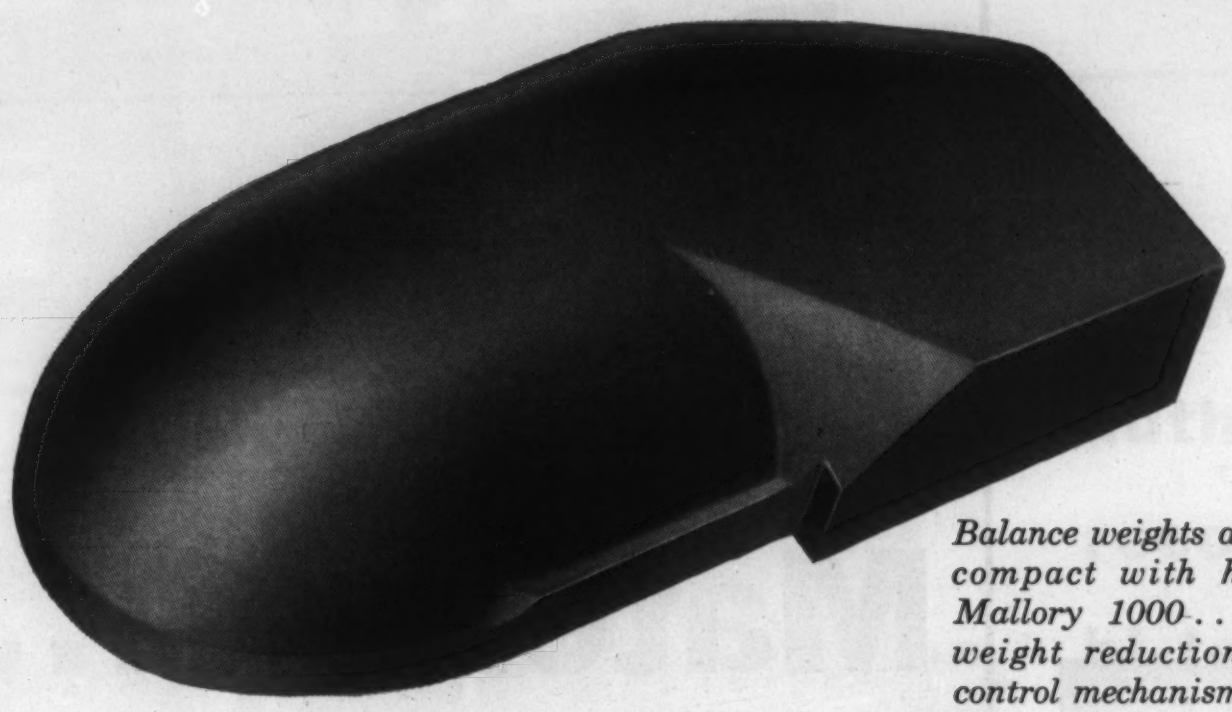
"Plastics can be engineered to meet the requirements of the industrial designer."

"For any large scale use, the plastics industry can offer a multitude of materials specifically designed for a single end product. Formerly the designer was limited by material properties, but plastics are an extremely diversified group of products which can be formulated to meet any requirements which the designer may specify. This factor alone should have a great influence on the future of the plastics industry if the industrial designer can be persuaded to come to the industry for recommendations concerning a specific end use.

"In many instances, the designer can make plastics serve two or more functions in the final product. For instance, in switch-gear boxes plastics form the supporting housings, but because plastics are also insulating materials the electrical structures are molded into the product as a part of the housing. In some applications mountings can be incorporated into the plastics structure in one molding operation as contrasted with metal where mountings must be welded in after fabrication.

"Another design advantage that cannot be overemphasized is the availability of plastics materials. Our natural resources of the materials needed to produce plastics are virtually unlimited. It seems only common sense to me that industrial designers would choose plastics as their material of construction whenever possible. Not only do plastics provide increased design flexibility, but plastics also give no hint of plaguing the product-producing industries with shortages and consequent high prices."

MALLORY



Balance weights are made more compact with high density Mallory 1000 . . . with overall weight reduction in aircraft control mechanisms and similar devices.

Designing for weight savings . . . with High Density Mallory 1000 Metal

SAVING weight by using a *heavier* metal is not as contradictory as it seems at first glance. Here is how Mallory 1000 Metal can help you do this.

With its exceptionally high density of 16.96 gm/cc, Mallory 1000 makes it possible to reduce the physical size of counterbalances, balance weights and similar "mass components". Shrinking the size of these units often allows you to cut the dimensions of housings, linkages and other structural elements . . . and thus effect substantial savings in overall weight of the assembly.

Of particular interest to designers is the exceptional uniformity of characteristics offered by Mallory 1000. Its density, tensile strength, modulus of rupture and elongation are held to accurate limits. You can base your calculations on *actual* rather than vague "typical" properties. It leads all other high density metals in its adherence to firm specifications . . . and it offers a combination of weight, strength and machinability that has no equal.

We invite you to investigate the characteristics of Mallory 1000 for any use you have which requires concentrated mass or inertia, in balance weights or rotating elements. Write today to Mallory for complete technical data.

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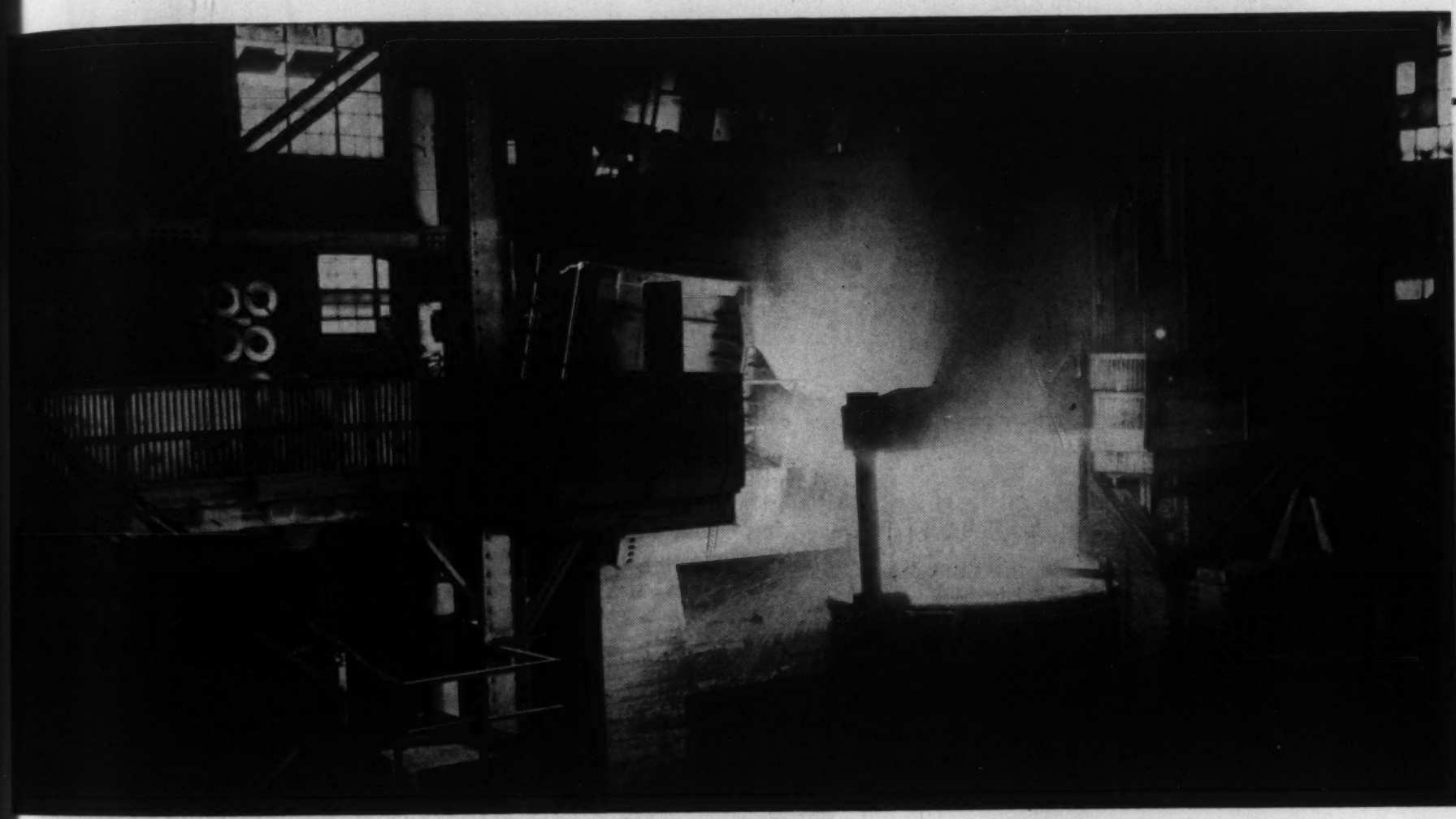
MATERIALS ENGINEERING NEWS

This month

- ▶ *Steel price to rise*
- ▶ *Vacuum melting grows*
- ▶ *Other News starting p 234*



***New capacity construction** and replacement of obsolete equipment will cost the steel industry between $1.1 and $1.5 billion during the next five years.*

New wage increases, added capacity mean...

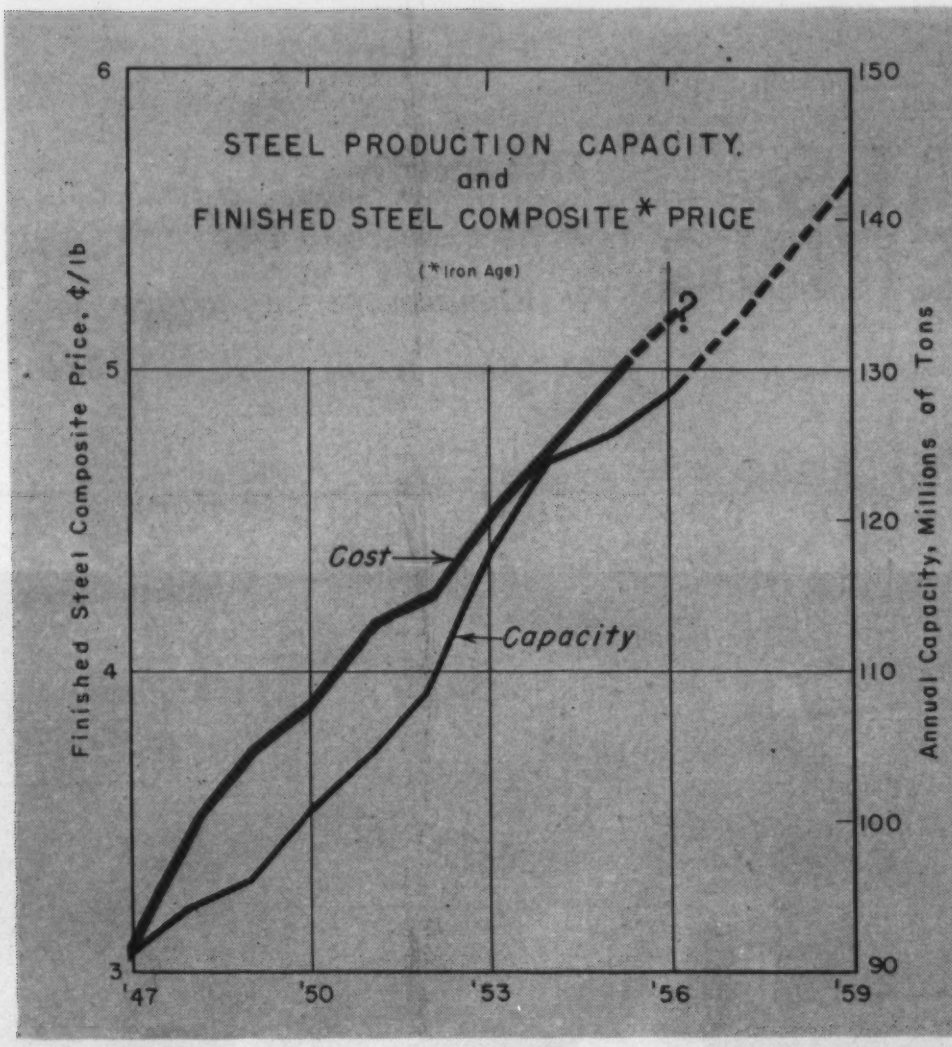
Steel Prices Will Continue Steady Upward Climb

■ Steel users are steadily losing all hope of seeing steel prices stabilized for any protracted period of time. Apart from the effect of the strike and future union demands, steel industry officials emphasize the need for a price increase to offset depreciation costs and the expense of building new capacity.

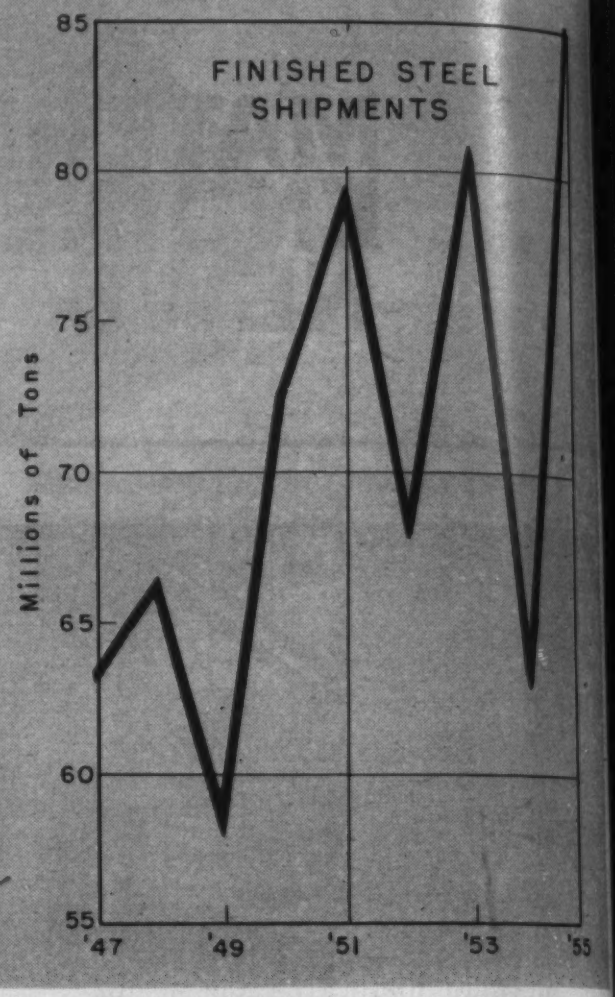
Current plans call for the spending of $1.1 to $1.5 billion in each of the next five years to replace facilities that wear out and become obsolete. In addition, the industry plans to add another 15 million tons to the nation's steelmaking capacity during the next three years. This new expansion will bring the total steelmaking capacity to 143 million tons by 1959.

Two problems

Spokesmen for the industry point out that they are faced with two problems: 1) In replacing obsolete equipment, the total amount they can recover under depreciation provisions of existing tax law will fall about $3 bil-



Cost of adding *new steel producing capacity is reflected in finished steel price.*



Steel shipments *have been erratic but show an over-all growth trend.*

lion short of doing the job. 2) The construction of new capacity cannot be adequately financed from the earnings of the industry.

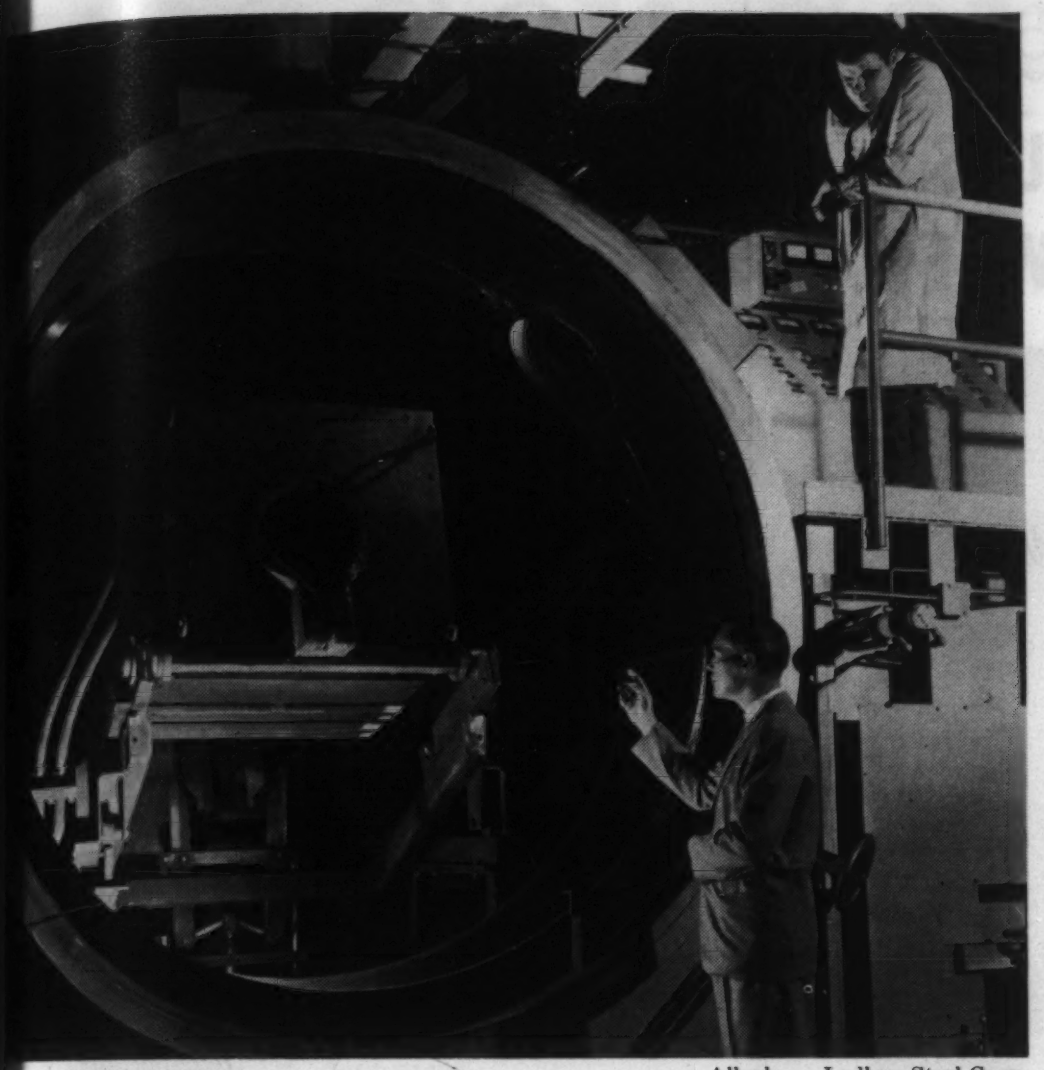
Although the industry has taken full advantage of technological improvements in reducing costs, the earning powers of the companies have not materially increased. In other words, the steel suppliers point out, the present price structure is not high enough to support production based on present day costs.

Production up

These remarks were made against the background of the record breaking production level of last year. The industry poured a total of over 117 million tons of ingots and steel for castings and shipped about 84.5 million tons of steel products. During the first five months of this year, the industry produced about 53 million tons of steel, an increase of 10% over the comparable period in 1955.

Steelmen admit that earnings have improved because of this high level of operations, but they add that from the long range point of view earnings of the steel industry have not been satisfactory for the last 30 yr.

Plastics Show exhibits attracted nearly 36,000 visitors during the recent exposition of more than 230 companies in New York City. More than 4000 attended the annual conference of the Society of the Plastics Industry, which ran concurrently.



Allegheny Ludlum Steel Corp.

Main vacuum chamber *contains 300-lb experimental furnace used for development program on a wide variety of steels.*

As data on 'clean' alloys accumulate...

Metal Producers Increase Vacuum Melting Capacity

Commercial and military designs continue to call for increasing quantities of steels with high purity and with uniform properties within heats. Steel users in the aircraft and electronic industries, in particular, are faced with exacting product design specifications that approach the upper performance limit of existing steels. These high performance demands can be seriously limited by slight impurity variations within heats.

Steel producers are striving to attain the standards demanded by these new designs by employing better refining techniques. Best method developed so far has been vacuum melting. Tests on 52100 ball bearing steel prepared by this method indicate that fatigue life is increased approximately 30%. Wear factor and impact strength of certain die steels have been increased as much as five times. Work on ferrous alloys in general shows vacuum melting improves tensile strength, impact resistance and ductility. Better electrical properties are obtainable and there is a marked improvement in both corrosion and abrasion resistance. All indications are that vacuum metals will have many applications where the factors limiting design or operation of equipment are metallurgical in nature.

The two most recent vacuum melting installations have been announced by Cannon-Muskegon Corp., Muskegon, Mich., and Allegheny Ludlum Steel Corp., Watervliet, N. Y.

Cannon-Muskegon

Cannon-Muskegon's furnace is equipped for pouring 300-lb heats and is primarily intended for production of iron, nickel and cobalt base alloys at temperatures up to 3000 F. The new furnace will be used to develop special alloys and to produce standard alloys. Much of its output will be in the form of cast bars for remelting by investment casters, the company's principal customers. However, cast ingots and billets up to 250 lb will also be produced, and the furnace will be available for development work on vacuum castings.

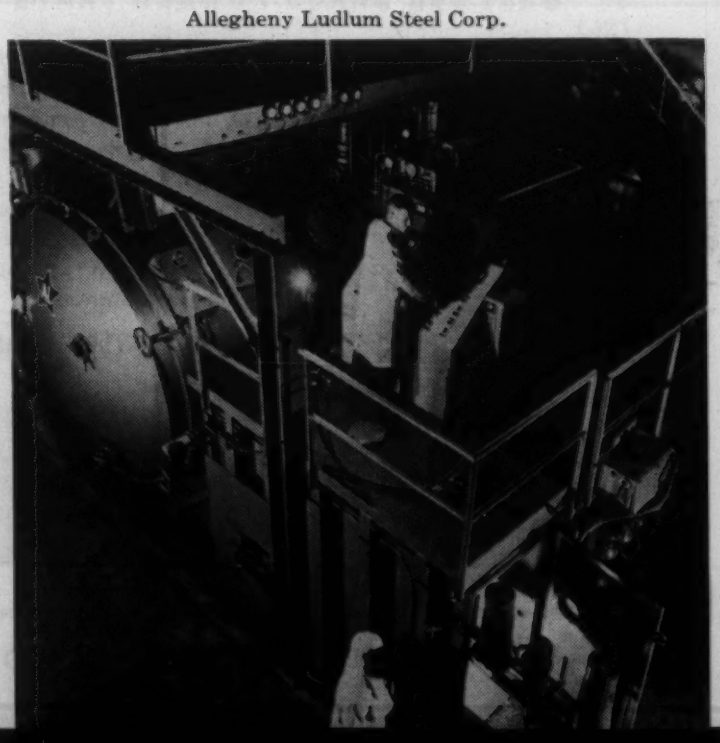
Cannon-Muskegon's aim for 1956 is a production rate of 20,000 lb per month. Eventually, it is hoped, this rate can be increased by using larger melts and more pumps. For the present, vacuum alloys will be priced about $3.00 per lb above corresponding air melted alloys.

Allegheny Ludlum

Allegheny's new induction vacuum furnace is a 300-lb experimental installation. After a period of research, the company plans to replace this furnace with

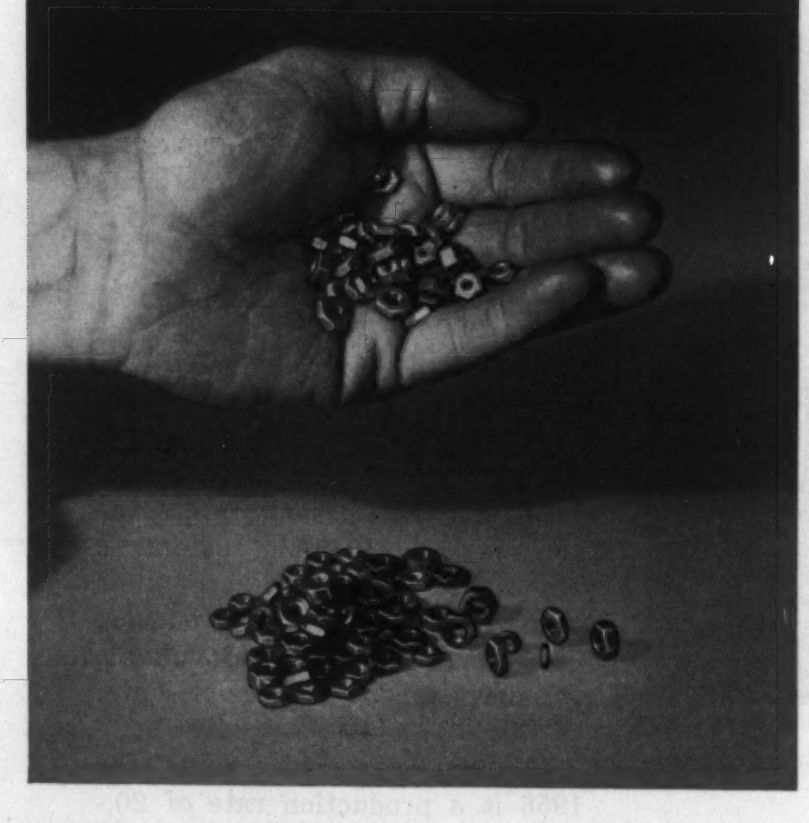
(continued on p 234)

Allegheny Ludlum Steel Corp.



Hot ingots *exit from vacuum chamber of the induction vacuum melting furnace (located in tank at left).*

NOW! BRASS HEX NUTS MADE FROM POWDER



Tradition in nut manufacturing is giving ground to production by powder metallurgy—with spectacular results. Brass powder nuts can be made with clean-cut detail and a high degree of dimensional control. The manufacturer* claims ultimate tensile strengths of 30,000 to 35,000 psi for the new brass powder nuts and prices which show definite savings over those produced by conventional methods.

Brass powder nuts are made by compacting and sintering blanks, which are then cut-threaded to conform to rigid specifications. The smooth surfaced bright brass appearance of the nuts is most attractive. They are also available with cadmium, zinc or nickel plated coatings, or with a black oxide finish. Widths from 5/32" to 9/16" and thicknesses from 3/64" to 19/64" are now in production with a wide range of hole and thread sizes.

*Midwest Sintered Products Corp., Chicago, Illinois

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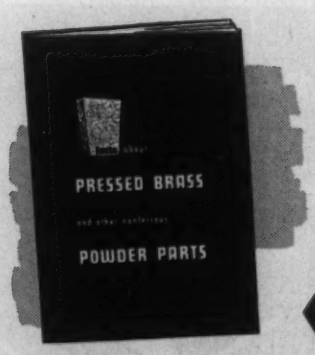

For detailed information on the design, properties, production and application of brass and other nonferrous powder parts you should have a copy of our manual. It will give you 20 case histories of brass and nickel silver powder structural parts to assist in evaluating this means of production in terms of your particular needs.

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LETTERS TO THE EDITOR

Make File Facts handier

To the Editor:

I have continued to enjoy your magazine for a number of years. The articles are to the point, have diversification, and keep me interestingly informed. The Manuals are fine references on their various subjects, and I keep them all. However, the "Engineering File Facts" could be more useful. I note that you contemplate your readers cutting them out and putting them in a loose-leaf cover. But "File Facts" are no good unless they can be found. I suggest:

1. Print File Facts on both sides of the sheet. I don't like to hoard the ads. Keep each page (sheet) the same subject.

2. Issue an index, and give each "File Fact" a place in the index. . . .

If such is already planned, do you plan to issue a new portfolio? If so, I'd be one of the first to subscribe.

STEPHEN W. AKIN
Schenectady, N. Y.

The suggestions are timely, interesting and under consideration.

We're unkind to postman

To the Editor:

Three months ago I sent you a change of address but I am still paying 16¢ each month postage due, due to the forwarding from the old address.

Now don't get me wrong, fellas, it isn't cause I'm cheap or that MATERIALS & METHODS isn't worth it. On the contrary, it is worth a college refresher course practically each month. There are two reasons why I wish you would change the address. First, we have a little skinny postman and he has to carry the magazine with him all day and then back to the P.O. because we are never at home during the day. Second, the only time we can get to the P.O. is on Saturday, so what happens? I fret and stew for three or four days wondering what is in the latest issue, so change it, will ya fellas? Please?

LAROY R. MASON
Pasco, Wash.

Our apologies to reader Mason. Changing our mailing plates does take a little time, however, so please give us advance warning of a move whenever possible.

Problem: coring stainless

To the Editor:

At the present time one of our most pressing engineering problems in the field of hydraulic controls is that of designing and producing stainless steel control valve bodies with interior passages. In the past we have made aluminum valve bodies with internal coring, but due to higher operating tem-

(continued on p 250)

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August 1956

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Students and foreign subscribers (other than Canadian), please request literature directly from manufacturers.

MANUFACTURERS' LITERATURE

New Literature

Aircraft Bolts. Aero Supply Mfg. Co., Inc., 12 pp, illus. How aircraft quality bolts are made from original wire stock to finished precision product. (1)

Special Steels. Allegheny Ludlum Steel Corp., 16 pp. Data on stainless steel, electrical materials, Carmet carbide materials and tool steels. Also charts on analyses of various steels. (2)

Socket Screws. Allen Mfg. Co., 12 pp, illus., No. G20. Information on metal finishing standards for socket screws. (3)

Knitted Wire Products. Alloy Metal Wire Div., H. K. Porter Co., Inc. 8 pp, illus., No. A-1. Describes design features of knitted stainless steel and nickel alloy wire. Applications include filters, liquid entrainment separators, shock isolation cushions and electronic weather stripping. (4)

Manganese Steel Castings. American Manganese Steel Div., American Brake Shoe Co., 24 pp, illus. Why manganese steel should be specified when impact and abrasion are major causes of wear. Details on production and application of "the toughest steel known." (5)

Technical Ceramics. American Lava Corp., 4 pp, illus., No. 563. Mechanical and electrical properties of AlSiMag technical ceramics. (6)

Welding Fittings. Babcock & Wilcox Co., Tubular Products Div., 6 pp, illus., No. FB-500. Types and size ranges of various welding fittings and flanges. (7)

Controlled Gray Iron. Barnett Foundry & Machine Co., 12 pp, illus., No. 39. Why an increasing number of specifications call for Meehanite metal for cams, camshafts and crankshafts. (8)

Heat Treating Beryllium Copper. Beryllium Corp., 8 pp, graphs. Methods and procedures of heat treating beryllium copper wrought and casting alloys. (9)

Bar Steels. Bliss & Laughlin, Inc., 4 pp, illus., No. 55. How Strain-Tempered bar steels improve products and reduce costs. Typical applications include shift spur gears, main drive splines, machine shafts and snapping roll drives. (10)

Stressed Panel Fastener. Camloc Fastener Corp., 6 pp, illus., No. SPF 56. How the Camloc SPF fastens and unfastens with less than a full turn and still provides positive clamping without deflecting under load. (11)

Cemented Oxide Tools. Carboloy Dept., General Electric Co., 4 pp, illus., No. GTO-103. Information on cemented oxide 0-30. Covers metals machined to date, tool holders required, cutting angles, chip control, cutting speeds, and feeds, coolants and other tooling information. (12)

PVC Pipe, Fittings. Carpenter Steel Co., Alloy Tube Div., 6 pp, illus. Lists advantages of normal impact and high impact grades of unplasticized polyvinyl chloride pipe and fittings. (13)

Clear Rigid Plastics. Cast Optics Corp., 12 pp, illus. Lists uses, advantages and properties of five optically clear rigid plastics sheets. Also explains engineering service. (14)

Injection Molding Cellulosics. Celanese Corp. of America, Plastics Div., 7 pp, illus., No. A-16. "Fundamentals of Injection Molding Cellulosics." (15)

Low Melting Alloys. Cerro de Pasco Corp. 4 pp. Lists 63 known applications—most of them in the metalworking field—for Cerro nonshrinking, low melting alloys. (16)

Brass Die Pressed Forgings. Chase Brass & Copper Co., 4 pp, illus. Three-dimensional photographs seen through colored glasses show the difference between the same articles made as die pressed brass forgings and as brass sand castings. (17)

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Circular Steel Parts. Cleveland Welding Co., 26 pp, illus. Describes the Cleve-Weld Process and shows how specialized production facilities and know-how can save money on circular steel parts. (18)

Refractory Molybdenum Borides. Climax Molybdenum Co., 6 pp, No. Cdb-8. Applications, properties and preparation of six molybdenum borides. (19)

Nonmetallic Gear Material. Continental-Diamond Fibre Div., Budd Co., Inc., 15 pp, illus., No. C-56. Catalog on Celoron, a synthetic resin—impregnated material that is ideal for gears because it is tough, resilient, strong and has controlled electrical properties. (20)

Copper and Brass. Copper & Brass Research Assn., 16 pp, illus. *Copper & Brass Quarterly* covers selected applications. (21)

Precision Castings. Corning Glass Works, 20 pp, illus., No. GC-2. Describes Glascast molding process that offers: quick tool-up, precision casting to tolerances of 0.005 in. per in., fine surface finish and less scrap loss. (22)

Castings. Curtiss-Wright Corp., Metals Processing Div., 10 pp, illus. Describes facilities for research, development and quantity production of castings that meet critical requirements. (23)

Grooved Fasteners. Driv-Lok Pin Co., 24 pp, illus. Catalog of Driv-Lok pins and studs and precision Lok-Dowels. Lists materials that can be used and shows typical applications. (24)

Urethane Foams. E. I. du Pont de Nemours & Co., Inc., Elastomers Div., 4 pp, illus. Lists properties of rigid and resilient urethanes and suggests a wide variety of uses for these strong, lightweight cellular materials. (25)

Castings. Eastern Malleable Iron Co., 23 pp, illus. Discusses merits and applications of popular Eastern alloys. Also shows facilities for producing quality castings in Z metal, steel, malleable iron, aluminum, gray iron, nickel and chrome alloys and high strength irons. (26)

Plastics Injection Molding. Eastman Chemical Products, Inc., 51 pp, illus. Injection molding of Tenite acetate and butyrate. Discusses principles of design and includes a guide for correcting molding difficulties. (27)

Bridge Amplifier Meter. Ellis Associates, 2 pp, illus., No. 6. Describes BAM-1 bridge amplifier and meter that measures strain, stress load acceleration pressure and vibration displacement. It is used for both dynamic and static work with SR-4 strain gages. (28)

Stainless Steel Castings. Empire Steel Castings, Inc., 2 pp, No. 156-H. Chart for heat resistant stainless steel castings correlates ACI (and Empire) designations with corresponding AISI and ASTM designations. (29)

Compounds, Abrasives. Esbec Barrel Finishing Corp., 2 pp. Covers specifications and applications of 14 Esbec color coded compounds and abrasives. A chart recommends compound types for various materials and different finishing operations. (30)

Bimetallics. Fairchild Engine & Airplane Corp., Al-Fin Div., 4 pp, illus. Latest issue of *Bonded Bi-Metallics News* covers case histories illustrating successful use of Fairchild's process for bonding aluminum and magnesium to ferrous metals. (31)

Custom Metal Fabrication. Falstrom Co., 2 pp, illus. Describes facilities for custom fabrication of mild and stainless steels, aluminum and alloy metal parts. (32)

Plastics Laminates. Farley & Loetscher Mfg. Co., Plastics Div., 8 pp, illus., No. 1933. Catalog of Farlite industrial and decorative plastics laminates. (33)

PVC Pipe, Valves, Fittings. Peter A. Frasse & Co. Inc., 8 pp, No. 13. Describes rigid unplasticized polyvinyl chloride pipe, fittings and valves. Covers corrosion resistance, general properties, fabricating characteristics and economies. (34)

Fluorocarbon Lining. Garlock Packing Co., 2 pp, illus. Shows applications of a Kel-F plastic laminate as a lining material. Nontoxic, noncontaminating Kel-F resists acids, alkalies, oxidants and solvents. (35)

Rigid Vinyl Extrusion Compound. General Tire & Rubber Co., Chemical Div., 11 pp. Introduces Vigen 1101, a new Type 1 rigid vinyl compound blended especially for extruding operations. Data on advantages, limitations, processing characteristics, physical and chemical properties and chemical resistance. (36)

Precision Casting. R. W. Greeff & Co., Inc., 18 pp. Use of ethyl silicate investment for precision casting. Describes the hydrolysis, gelation, setting and hardening of ethyl silicate; precoat and investment preparation; typical formulas; and solutions of typical investment casting problems. (37)

Brazing Cemented Carbides. Handy & Harman, 8 pp, illus. Data on Easy-Flo No. 3 Trimetal, an alloy developed for sandwich brazing cemented carbide tips. Alloy provides extra shock resistance needed for heavy duty tools. (38)

Mobile Welding Generator. Harnischfeger Corp., 2 pp, illus., No. W-101. Data on a NEMA rated diesel engine drive d.c. welder with a welding service range of 60 to 375 amp. (39)

Salt Bath Furnace. Hevi Duty Electric Co., No. 655. Describes Hevi Duty Bellis Immersed Electrode Salt Bath Furnace that has a temperature range from 300 to 2400 F. (40)

Iron Powder. Hoeganaes Sponge Iron Corp., 4 pp, illus. Advantages of Ancor-Flame sponge iron powder in cutting, scarfing, gouging, lancing and washing. (41)

Metal Laminates. Improved Seamless Wire Co., 9 pp, illus. Describes lamination of precious metals to copper, brass, nickel, silver, Monel and pure nickel. These permanently bonded metals are supplied as sheet, wire and tubing. (42)

Beryllium Copper Springs. Instrument Specialties Co., Inc., 16 pp, illus., No. 9A. Data on precision beryllium copper springs. Explains Micro-Processing, describes engineering services and shows typical compression, flat and strip springs and contact strips and rings. (43)

Aluminum Bronze. International Nickel Co., Inc., 8 pp, illus. Report on the development of nickel-aluminum bronze for marine propellers and application of the material in aeronautical, power, electrical, metalworking and process industries. (44)

Electrical Tapes. Johns-Manville Dutch Brand Div., 12 pp, illus. Shows advantages and applications of four insulation tapes: plastic, friction, rubber and vinyl color tape. (45)

Expandable Polystyrene. Koppers Co., Inc., 12 pp, illus. An idea book of products that can be made with Dylite, an expandable polystyrene. (46)

Custom Glass. Lancaster Lens Co., 27 pp, illus. Catalog emphasizes design flexibility in glass. Shows lead glasses for electronics, heat resisting borosilicate glasses, lime glasses and many other special glasses. (47)

Steel Castings. Lebanon Steel Foundry, 4 pp, illus. Case histories of two aircraft steel castings now in quality production using Lebanon's Ceramicast Process. (48)

Steel Welding Electrodes. Lincoln Electric Co., 28 pp, illus., No. SB-1351. "Weldirectory for Mild Steel and Low-Alloy High Tensile Steels." Revised bulletin includes newest iron powder and other electrodes. (49)

Titanium. Mallory-Sharon Titanium Corp., 8 pp, illus. How to design away corrosion with titanium. Table shows corrosion ratings for titanium when exposed to corrosive agents. (50)

Seamless Tubing. Michigan Seamless Tube Co., 62 pp, illus. Describes manufacturing process and presents extensive data on mechanical, aircraft and pressure tubing. Contains 15 pages of formulas and references. (51)

Metal Powder Brass Nuts. Midwest Sintered Products Corp., 4 pp. Contains samples of brass nuts made by powdered metallurgy. Available with any desirable detail to close tolerance, brass nuts will maintain "as sintered" an ultimate tensile strength of 30-35,000 psi. (52)

Honeycomb Adhesives. Minnesota Mining & Mfg. Co., Adhesive & Coatings Div., 20 pp, illus. Data on adhesives for honeycomb structures. Discusses honeycomb sandwich materials, construction details and adhesive application procedures. (53)

Fiberglass Reinforced Plastics. Molded Fiber Glass Co., 16 pp, illus. Describes custom molding services. Lists fabricating operations and mechanical, electrical and chemical properties of molded fiberglass. (54)

Industrial Wire Cloth. Newark Wire Cloth Co., 4 pp, illus. Shows diversi-

Manufacturers' Literature

fied line of metallic wire cloth, screen and woven wire products produced in any commercial size, in all weaves and from all malleable metals. (55)

Expanded Perlite. Perlite Institute, 24 pp. "Perlite Brand Names Directory" for 1956. Lists more than 150 brand names, uses and addresses of manufacturers of this cellular expanded material obtained from volcanic lava rock. (56)

Masking Tapes. Permacel Tape Corp., 4 pp, illus. Describes three all-purpose masking tapes. Tapes resist staining by all but a few special finishes and resist oven temperatures up to 300 F for 20 min. (57)

Nameplates. Photo Chemical Products, 4 pp. Describes Photo Wrinlay process for making nameplates. Process, which uses baking enamel instead of lacquer, is applicable to panels, dials, schematics, chassis, cases and covers. (58)

Metal Powder. Plastic Metals Div., National-U.S. Radiator Corp., 12 pp, illus., No. 2. Company is oldest U.S. commercial iron powder producer. Facilities, applications and standard metal powders are described. (59)

Carbon Graphite. Pure Carbon Co., Inc., 12 pp, illus., No. 55. Catalog on carbon graphite for mechanical applications. (60)

Electrostatic Painting. Ransburg Electro-Coating Corp., 16 pp, illus. Explains electrostatic spray painting and shows the process used in the finishing of automobile chassis, refrigerator cabinets, door knobs, toys and other products. (61)

Silicones. Raybestos-Manhattan, Inc., 8 pp, illus. Features silicone rubber products and silicone coated cloths. Lists government specifications, resistance qualities, limitations and service recommendations for silicone rubber. (62)

Chemicals. S. W. Shattuck Chemical Co., 8 pp. Describes Shattuck's various molybdenum, uranium, vanadium and tungsten chemicals. (63)

Fasteners. Simmons Fastener Corp., 4 pp, illus. Details on five quickly installed fasteners—Dual-Lock, Link-Lock, Quick-Lock, Roto-Lock, Spring-Lock—that offer design flexibility, strength, positive locking and smooth fastening. (64)

Screws. Standard Pressed Steel Co., Unbrako Socket Screw Div., 30 pp, illus. Revised catalog shows size ranges and specifications for standard Unbrako fasteners. (65)

Welded Tubing. Standard Tube Co., 8 pp, illus. Describes quality production of stainless steel pipe and tubing, mechanical steel tubing and boiler, condenser and other pressure tubing. Shows products in military, mechanical, ornamental and other applications. (66)

PVC Parts. Stokes Molded Products, Div. of Electric Storage Battery Co., 6 pp, illus. How to cut replacement and maintenance costs with precision custom molded unplasticized polyvinyl chloride parts. Shows PVC's chemical resistance to more than 250 materials. (67)

Steel Castings. Tempil Corp., 40 pp. "Recommended Practice for the Welding of Steel Castings." Comprehensive manual published by the Steel Founders Society of America. (68)

Friction Materials. Thermoid Co., Industrial Friction Div., 4 pp. Discusses factors to be considered in selecting friction materials and presents a chart with extensive data on brake linings and clutch facings. (69)

Shafts, Rolls, Guide Rods. Thomson Industries, Inc., 1 p, illus. Describes "60 Case" hardened and ground shafts, rolls, guide rods and other long round parts, available in ¼ to 4 in. dia. (70)

Aircraft Lockbolts. Townsend Co., Cherry Rivet Div., 4 pp, illus. No. TCL-111. Describes Cherry Aircraft Lockbolts. Gives application procedures, ordering instructions and information on guns to install them. (71)

Neoprene Foam. Toyad Corp., 12 pp, illus. Shows applications and manufacture of Toyad neoprene foam as a cushioning material. Foam is resistant to flame, solvents, heat, aging, mildew, tearing and abrasion. (72)

High Finish Tubing. Tube Reducing Corp., 4 pp, illus., No. R7. Describes Rockrite process for producing tubing with close, uniform tolerances and superior i.d. surface finish that makes it "ideal for cylinder applications." (73)

Silicone Impregnating Varnish. Union Carbide & Carbon Corp., Silicones Div., 8 pp. Uses, properties and application procedures of R-620 silicone impregnating varnish for high temperature electrical insulation systems. (74)

Hardness Testing. Wilson Mechanical Instrument Div., American Chain & Cable Co., Inc., 12 pp, illus., No. DH-328. Describes Tukon Testers for micro and macro hardness testing. They are used for testing metallic and nonmetallic parts such as fine wire, small precision parts, thin metal, superficially hardened surfaces, jewels, plastics, glass. (75)

Other Available Literature

Irons & Steels • Parts • Forms

Weldments. American Welding & Mfg. Co., 23 pp, illus. Describes welding facilities. Also lists products and services. (80)

Stainless Fastenings. Anti-Corrosive Metal Products Co., Inc. Catalog lists stainless steel fastenings in stock. (81)

Chains. Bead Chain Mfg. Co., 12 pp, illus. Bead chain characteristics and applications are described. (82)

Low Alloy Steel. Bethlehem Steel Co., 66 pp, illus., No. 353. Properties and features of Mayari-R steel for use in applications requiring high strength and good wear and corrosion resistance. (83)

Alloy Comparison Chart. Cannon-Muskegon Co. Comparison chart of AISI, SEA, ACI, AMS, WAD and PWA alloy specifications. (84)

Nickel Plated Steel. Colorado Fuel & Iron Corp., Wickwire Spencer Steel Div., 12 pp. Describes electro-clad nickel-plated products, manufacturing techniques and fabrication procedures. (85)

Steel Sheets and Wire. Continental Steel Corp., 20 pp, illus. Contains sizes, tempers, shapes and finishes of wire available and describes types of steel sheet in stock. (86)

Lead Treated Steel. Copperweld Steel Co., Steel Div., 8 pp, illus. Mechanical properties and applications of lead treated steels. (87)

Iron Powders. Antara Chemicals Sales Div., General Aniline & Film Corp., 7 pp, graphs. Properties of types SF, J and W carbonyl iron powders. (88)

Metal Stampings. Geometric Stamping Co., 4 pp, illus. Suggestions for cost savings through conversion from castings to stampings. (89)

Sheet and Plate Fabrication. Kirk & Blum Mfg. Co., 38 pp, illus. Describes facilities and equipment used in production of metal sheet and plate (90)

Stainless Steel Castings. Kolcast Industries, Inc., 4 pp, illus. Shows large stainless steel precision castings made by the frozen mercury process. (91)

Weldless Rolled Rings. Ladish Co., 4 pp, illus. Advantages and applications of high strength weldless rolled rings produced in weights up to 20 tons. (92)

Welded Assemblies. R. C. Mahon Co., 1 p, illus. Several examples show the capabilities of welding for construction of various assemblies. (93)

Metal Powder Parts. Metal Powder Products, Inc., 4 pp, illus. Shows the diversity of applications for iron, iron-copper and bronze sinterings made by this company. (94)

Threaded Stampings. Mohawk Mfg. Co., 2 pp, No. 851. Illustrates variety of products produced by Mohawk's stamping processes, which guarantee uniform threaded parts. (95)

Screw Machine Products. National Screw Machine Products Assn., 74 pp. NSMPA 1955-56 Buying Directory lists more than 270 firms alphabeti-

cally and geographically. Also gives conditions of sale and manufacturing practices for screw machine products. (96)

Small-Mesh Expanded Metal. Penn Metal Co., Inc., 4 pp, illus. Sizes, dimensions and weights of Minimesh, a small mesh expanded metal used for guards or grilles on stoves, heaters, radios and coin-operated phonographs. (97)

Seamless Mechanical Tubing. Pittsburgh Steel Co., 198 pp, illus. Applications, cost analysis, production techniques, inspection methods, tolerances, chemical composition, physical properties, and reference tables for seamless mechanical tubing. (98)

Custom Steel Parts. Henry Disston Div., H. K. Porter Co., Inc., 16 pp, illus. Describes custom steel parts, how they are made and how to use and order them. (99)

Iron Powder. Pyron Corp., 8 pp, No. 1. Technical information on hydrogen reduced and electrolytic iron powders. Sintering data, effect of infiltrants, dimensional stability, strengths, etc. (100)

Powder Metal Parts. Reese Metal Products Corp., 1 p. Describes advantages of and techniques for making powder metal parts. (101)

Steel Tubing. Rochester Products Div., General Motors Corp., 12 pp, illus., No. 271. Typical applications of GM tubing made in both single and double walls of steel. (102)

Aircraft Steels. Joseph T. Ryerson & Son, Inc., 68 pp. Information on Army, Navy and government aircraft steel specifications. (103)

Spun Metal Parts. Spincraft, Inc., No. 3. Metal spinning and fabricating. Data on process and help in designing for economical production. (104)

Steel Tubing. Summerill Tubing Co., Div. Columbia Steel & Shafting Co., 8 pp, illus. Cold drawn steel tubing for hydraulic applications. (105)

Stainless Strip. Superior Steel Corp., 32 pp, illus. Technical information on 20 types of stainless strip steel. Includes table on weight per lineal foot of strip steel for various thicknesses and widths. (106)

Steel Tubing. Superior Tube Co., 4 pp. Working data for SAE hydraulic quality low carbon steel tubing. (107)

Malleable and Alloy Iron Castings. Texas Foundries, Inc., 20 pp, illus. Describes foundry facilities and provides case histories of applications of malleable iron. (108)

Wire Construction. E. H. Titchener & Co., 17 pp, illus. Detailed information on use of wire construction in product design. Case histories give examples of cost savings achieved. (109)

Weldments. Van Dorn Iron Works Co., 10 pp, illus. Facilities for producing weldments and other parts in all sizes. Examples show type of work done. (110)

Steel Strip. Weirton Steel Co., 20 pp, illus. Characteristics of electrolytic zinc coated sheets and strip, high tensile steel and high carbon strip cold-rolled spring steel manufactured by Weirton. (111)

Nonferrous Metals • Parts • Forms

Brazing Aluminum. Aluminum Co. of America, 744 Alcoa Bldg., Pittsburgh 19, Pa., 134 pp, illus. Describes brazing materials for aluminum and details the considerations involved in designing, preparing and assembling brazed joints. Request from Alcoa on company letterhead.

Precision Castings. Atlantic Casting & Engineering Corp., 12 pp, illus. How to obtain nonferrous castings cast to ordinary machining tolerances. Describes process and gives alloy specifications. (118)

Aluminum Alloy Castings. Morris Bean & Co., 4 pp, illus. Description, history, advantages, limitations and pattern making facilities for Antioch process aluminum alloy castings that meet exacting fluid flow specifications. (119)

Magnesium-Thorium Alloy. Brooks & Perkins, Inc., 28 pp. Design data on the new temperature resisting magnesium alloy, HK-31. Graphs and charts. (120)

Sintered Bronze. Bunting Brass & Bronze Co. 12 pp, illus., No. 56P. Information on stock bearings, flange stock bearings, washers and bars made of sintered bronze. (121)

Nickel Electrical Alloys. Driver-Harris Co., 94 pp, charts, No. R-56. Comprehensive catalog of special electrical and resistance alloys and fine gage nickel alloy wire and strip. Contains conversion tables, definitions, ASTM specifications. (122)

Lead-Base Babbitt. Graphitized Alloys Corp., 4 pp. Graphite-containing, lead-base babbitt metal as a substitute for high tin-base babbitt metals. (123)

Brass. Hampden Brass & Aluminum Co., 262 Liberty St., Springfield, Mass., 24 pp, illus. Describes manufacturing facilities of the company and of the Fibermold Div., which makes reinforced plastics. Request from Hampden on company letterhead.

Screens, Fabricated Metals. Hendrick Mfg. Co., 132 pp, illus. A 75th anniversary catalog on perforated metals, screens and fabricated metals. Typical uses, designs, sizes and engineering data. (125)

Investment Castings. Hitchiner Mfg. Co., 12 pp, illus. Description of precision investment casting and its advantages and limitations. (126)

Die Castings. Hoover Co., 12 pp, illus., No. 853. Shows facilities for producing zinc and aluminum die castings. Includes design aids and applications. (127)

Investment Casting. Howard Foundry Co., 8 pp, illus. Description of the new design freedom obtainable through use of investment castings. (128)

To obtain literature listed on these pages, use the convenient prepaid post card on pp 69 and 70.

Aluminum Extrusions. Kawneer Co., Aluminum Mill Products Div., 4 pp, illus. Describes completely integrated (pig through extrusion) facilities for producing shapes, rod, bar and tubing. (129)

Die Castings. Lester Castings, Inc., 4 pp, illus. Shows facilities for producing die castings. (130)

Rare Earths. Lindsay Chemical Co., 12 pp, illus. Describes company's work in the rare earth field. (131)

Metal Alloy Products. Little Falls Alloys, Inc., 2 pp, illus. Lists copper, titanium, aluminum and nickel alloys available and the use of these alloys in various products. (132)

Die Castings. Litemetal DiCast Inc., 12 pp, illus. How to select best light metal for die casting. Shows facilities for producing light metal pressure die castings. (133)

Titanium. Metal Hydrides, Inc., 2 pp, No. 600-C. Data sheet on titanium metal and facts on storage and handling. (134)

Thermostat Metal. Metal & Controls Corp., General Plate Div. Information on selecting thermal elements and their design. Tables give major mechanical and physical constants for various thermostat metals. (135)

Forgings. Mueller Brass Co., 33 pp, illus. Brass, bronze and aluminum forgings. Chemical, mechanical and physical properties of forging alloys, forging procedures, design factors and machining. (136)

Aluminum Core. Narmco Metlbond Co., 6 pp. Formable core material for aluminum sandwich constructions where application requires small radius curves. (137)

Thin Metal Strip. Penn Precision Products, Inc., 8 pp, No. 7. Case histories and data on thin gage (down to 0.5 mil) beryllium copper, phosphor bronze, nickel silver, chromium copper, 17-7PH stainless, invar and magnetic alloy strip. (138)

Aluminum Castings. Permold Co., illus. Shows how continuous scientific control of Permold aluminum casting quality saves time and money. (139)

Investment Casting Alloys. Precision Metalsmiths, Inc. Chart covers stainless, low alloy and tool steels, nickel alloys, copper-base alloys and aluminum alloys. Complete chemical analysis and mechanical properties given. Chart rates alloys as to castability, machinability, corrosion resistance, etc. (140)

Metal Designs. Rigidized Metals Corp., 2 pp. Folder contains four metal samples. Company has more than 40 standard patterns, some of which are shown in photographs. (141)

Nonferrous Alloys. Riverside Metal Co. A reference guide to alloy specifications of phosphor bronze, nickel silver, cupro nickel and beryllium copper. (142)

Aluminum, Magnesium Castings. Rolle Mfg. Co., 58 pp, illus. Guide to design and specification of aluminum and magnesium, sand, permanent mold and die castings. Discusses advantages and disadvantages of casting methods and

gives properties of common aluminum and magnesium casting alloys. (143)

Investment Castings. Scott Casting & Mfg. Co., 20 pp. Explanation of lost wax process. Limitations, sizes and weights of parts, castable metals and alloys. General information on costs and applications. (145)

Stamping and Perforating. Standard Stamping and Perforating Co., 114 pp, illus. Catalog of standard stamped and perforated patterns. (146)

Brass Pressure Die Castings. Titan Metal Mfg. Co., 4 pp, illus. Outlines economical uses of brass pressure die castings as fabricated assembly parts. (147)

Electronic Materials. Sylvania Electric Products, Inc., Tungsten & Chemical Div. Series of data sheets on tungsten, molybdenum, semiconductor, plated wire, chemical and phosphor products. (148)

Precision Castings. Universal Castings Co., 4 pp, illus. Technique of pouring at low temperatures and under vacuum as used in casting precision impellers. (150)

Super Alloys. Universal-Cyclops Steel Corp., 20 pp, illus. High strength, corrosion resistant alloys for gas turbines, turbo-superchargers, rockets and guided missiles. (151)

Stampings. Variety Machine & Stamping Co., 4 pp, illus. Describes plant facilities and types of stampings produced. (152)

Nonmetallic Materials • Parts • Forms

Molding Compound. American Cyanamid Co., 6 pp. Technical data on glass fiber filled melamine-formaldehyde molding material. (158)

Wool Felt. American Felt Co. Includes Dept. of Commerce bulletin Commercial Standard 185-52 Wool Felt. Contains more than 45 reference samples of industrial felts. (159)

Extruded Plastics. Anchor Plastics Co., 12 pp, illus. Applications of thermoplastic rods, tubes and shapes. Summary of properties of plastics materials with usage table. (160)

Fiberglass Reinforced Plastics. Apex Electrical Mfg. Co., 4 pp, illus. Case histories of custom molded fiberglass parts featuring pressure vessels. (161)

Gasket Materials. Armstrong Cork Co., 24 pp, illus. Complete data on various cork and rubber gasket materials made to meet government specifications. (162)

Nonmetallic Linings. Automotive Rubber Co. Eleven actual specimens of rubber and plastics compounds used in most corrosion and abrasion resistant lining work done by this company on tanks, vessels, pipe, fittings, duct work, fans and other equipment. (163)

Woven Glass Roving. Bigelow Fiber Glass Products Div., Bigelow-Sanford Carpet Co., Inc., 2 pp. Describes mechanically bonded glass fabric used in reinforced plastics, and lists advantages. (164)

Phenolic Resins. Borden Co., Chemical Div., 8 pp, illus. Durite phenolic molding compounds, bonding resins and impregnating resins. (165)

Compounded Elastomers. Chicago Rawhide Mfg. Co., 32 pp, illus. Characteristics, properties and engineering applications of Sirvene compounded elastomers. (166)

Contact Pressure Laminating Resins. Ciba Co., Inc., 17 pp, No. 1. Data on Araldite contact pressure laminating resins. Includes technical and electrical properties, charts and tables, mold preparation, glass fiber reinforcement and manufacturing procedures. (167)

Fiberglass Reinforced Parts. Clearfield Plastics, Inc., 22 pp, illus. Facilities for producing molded contoured parts. Suggests design and specification techniques. (168)

Vacuum Forming. Coating Products, 2 pp, illus. Bulletin on vacuum forming method of molding thermoplastic sheets. (169)

Vinyl-Metal Laminates. Columbus Coated Fabrics Corp., 14 pp, illus. Information on semirigid vinyl sheeting that eliminates the need for finishing. Col-O-Vin can be bonded to steel or nonferrous metals. (170)

Molded and Extruded Rubber. Continental Rubber Works, 8 pp, No. 100. Dimensions of molded and extruded rubber with cross sectional illustrations. Also condensed SAE and ASTM specification chart. (171)

Teflon Gaskets, Packing. Crane Packing Co., 12 pp, illus., No. T-103. Data on Chemlon packings and gaskets fabricated from Teflon tetrafluoroethylene resin. (172)

Custom Laminations, Extrusions. Dobeckmun Co., 4 pp, illus. Describes facilities for custom lamination of customers' materials or specialized conversion of films, foils and papers for applications such as pipe wraps, duct facing and packaging. (173)

Finish for Glass Cloth. Dow Corning Corp., 2 pp, No. 8-405. Data on water dilutable silicone finish for glass cloth. Can be used with epoxy, phenolic, polyester and silicone resins. (174)

Electroformed Molds. Electromold Corp., 4 pp. Gives details of electroforming process for plastics molds. (175)

Molding Compounds. Fiberite Corp., 1 p, No. 6. Lists phenolic, melamine and other resin-base molding compounds. (176)

Laminating Materials. Flexfirm Products. A folder with seven technical bulletins, Nos. 1, 2, 3, 111, 112, 113, 105. Also fabrication instructions for polyester resin-impregnated glass cloth and mat supplied in dry state ready for layup. (177)

To obtain literature listed on these pages, use the convenient prepaid post card on pp 69 and 70.

Paper-Base Laminates. Formica Co., 4 pp, illus. Physical data and uses of Formica XXXP-36. (178)

Ceramics. Frenchtown Porcelain Co., 7 pp, illus., No. 955. Quality control and production methods are pictured and a properties chart is included. (179)

Plastics Products. General American Transportation Corp., Plastics Div., 10 pp, illus. Brochure shows plant facilities for production from blueprint through assembly and packing. Also lists wide variety of molded plastics. (180)

Industrial Laminates. General Electric Co., 8 pp. How to select particular grade of laminated plastic sheet applicable to a specific design problem. Charts give description, properties and applications. (181)

Silicone Rubber Parts. General Electric Co., Plastic Dept., 4 pp, illus. Fabrication of silicone rubber parts for industry. Includes basic properties chart. (182)

Coated Fabric. General Tire & Rubber Co., Textileather Div., 6 pp, illus. Introduces Nygen Tolex and nylon reinforced coated fabrics. (183)

Plastic-Faced Plywood. Georgia-Pacific Plywood Co., 14 pp, illus. Advantages of GPX plastic-faced plywood used for cabinets, industrial counters, assembly line tables, etc. (184)

Latices for Textiles. B. F. Goodrich Chemical Co., 16 pp. Service bulletin on use of Hycar latices in textiles. Includes chart showing physical properties of Hycar latices in typical fields of application. (185)

Synthetic Rubber. Goodyear Tire & Rubber Co., Chemical Div., 24 pp, illus. Types and applications of Plioflex rubber and Pliolite latex. Also production and laboratory facilities. (186)

Plastics. Heil Process Equipment Corp., 4 pp, illus., Vol. 4, No. 1. Suggests applications for Rigidon, a glass-reinforced plastic; Rigidin, a rigid vinyl plastic; and Rigidene a polyethylene plastic. (187)

Adhesives and Coatings. Houghton Laboratories, Inc., 96 pp. Bound volume of technical bulletins covering adhesives, coatings and plastics materials. (188)

Balsa Wood. International Balsa Corp., 19 pp. Factual report on balsa wood, its growth, production, processing and uses. (189)

Pipe and Block Insulation. Johns-Manville, 12 pp, illus. Information on Thermobestos, a hydrous calcium silicate insulation for hot outdoor piping and process equipment operating at service temperatures up to 1200 F. (190)

Industrial Tape. Kendall Co., Polyken Products Dept., 4 pp. Sixteen pressure-sensitive tape samples with accompanying specifications and properties. Explains basic industrial tape applications. (199)

Iron-Like Wood. Lignum-Vitae Products Corp., 16 pp. Mechanical and industrial applications of lignum-vitae, a hard tropical wood with a density almost equal to that of iron. It is noncontaminating, acid and chemical resistant, and self-lubricating. (192)

Plastics Moldings. P. R. Mallory Plastics, Inc., 4 pp, illus. Complete production facilities for large scale production of custom molded parts from design to finishing and assembly. (193)

High Impact Thermoplastic Resin. Marbon Corp., 20 pp, No. CY-2. Processing recommendations, physical data, chemical resistance data and results of aging tests for Cycolac, a resinous polymer in which the basic material is styrene. (194)

Reinforced Wood. Met-L-Wood Corp., 15 pp, illus., No. 521. Describes combined wood and metal sheets, providing light weight and high strength. (195)

Electrical Insulation. Minnesota Mining & Mfg. Co., Irvington Varnish & Insulator Div., Irvington, N. J. Loose leaf binder catalog of flexible electrical insulation materials. Includes charts and conversion tables. Request from Irvington on company letterhead.

Carbon Specialties. Morganite, Inc., 12 pp, illus. Design data reference for carbon specialties, including chemical and physical properties, and typical blank sizes and parts. (196)

Vulcanized Fibre. National Vulcanized Fibre Co., 18 pp, illus. How vulcanized fibre is made; its outstanding properties; shapes and grades available; and typical applications. (197)

Metal Laminate. O'Sullivan Rubber Co., 4 pp. Describes Sullvyne-Clad metal laminate, a vinyl plastic sheeting bonded to metal to form a prefinished material. Includes physical and chemical properties of laminate. (198)

Ferromagnetic Plastic. Polypenco Products, Polymer Corp., 13 pp, graphs. Ferrotron, ferromagnetic plastic, is expected to open new fields of design in electronics. Available in rigid magnetic cores and flexible rod and tape, it has good magnetic and dielectric properties and good flexibility. (200)

Corrosion Resistant Gasketing. Products Research Co., 5 pp, illus. Features advantages and specifications of Chromelock corrosion resistant gasketing material. (201)

Molded Rubber Products. Roberts Toledo Rubber Co., 16 pp, illus. Describes facilities for producing molded rubber parts. (202)

Gasket Materials. Rogers Corp., 12 pp. Recommendations for using Duroid gasket materials. Also data sheets on seven specific gasket sheeting materials, which include a general description, typical test values and service recommendations. (203)

Paper Chemicals. Rohm & Haas Co., 2 pp. Revised price list for paper chemicals incorporating reductions in price of several products. (204)

Rubber. Roth Rubber Co., 1860 S. 54 Ave., Chicago, Ill. Actual rubber samples with hardness from 5 to 100 durometer. Kit is accompanied by ASTM specifications and list of uses for each sample. Offer limited to engineers and rubber buyers only. Request Roth Rubber Sampler No. MM3 from Roth Rubber Co., on company letterhead.

Plastics Extrusions. Schwab Plastics Corp., 20 pp, illus. Rigid and flexible plastics extrusions and plastics fabrications. (216)

Industrial Tape. Seamless Rubber Co., Industrial Tape Div., 60 pp, illus. Industrial tape catalog lists properties and pictures various types of tape. Includes breakdown of tape use in specific industries. (205)

Plastics Moldings. Sinko Mfg. & Tool Co., 4 pp, illus. Facilities for producing molded parts and products. Automatic injection molding machines have capacities ranging from 4 to 60 oz. (206)

Flexible Teflon Tubing. Sparta Mfg. Co., 4 pp. Properties and characteristics of Teflon thin walled and spaghetti tubing. Suggested uses include: instrument tubing, electronic applications, wire sheathing, acid lines, steam or other high temperature lines. (207)

Plastics Laminates. Spaulding Fibre Co., 16 pp. Detailed breakdown of industry applications for vulcanized fibre and laminated phenolic plastics. (208)

Rubber. Sun Rubber Co., 22 pp, illus. Facilities for processing, curing and finishing rubber products. (209)

Laminated Plastics. Synthane Corp., 4 pp, illus. Military, government and other specifications for Synthane laminated plastics sheets, tubes and rods. (210)

Fabricating Laminated Plastics. Taylor Fibre Co., 15 pp. Reprints of NEMA authorized engineering information, "Recommended Practice for Fabricating Laminated Plastics." (211)

Nylon Screws. Weckesser Co., 3 pp, illus. Describes black nylon screws and nuts and use in design problems. (212)

Industrial Fibers, Textiles. Wellington Sears Co., 26 pp, illus. Properties of industrial textile fibers, including cotton, rayon, acetate, nylon, acrylic, polyester, glass, vinyl and protein. Defines yarn designations, basic weaves and variations as used in fabrics. How fabrics are selected for use with rubber; as coated fabrics; in laminated plastics; for filtration purposes; and in other applications. (213)

Synthetic Rubber Products. Western Felt Works, Acadia Synthetic Products Div., 6 pp, illus. Shows various types of molded, extruded, roll die cut and lathe cut synthetic rubber parts and sheets. (214)

Sealing Design. Franklin C. Wolfe Co., Inc., 4 pp, illus. Describes facilities and products for sealing bolts, studs, rivets and flanges. (215)

Finishes • Cleaning and Finishing

Colloidal Dispersions. Acheson Colloids Co., 4 pp. Revised list of 44 colloidal and semicolloidal dispersions for operational functions, maintenance, lubrication, machine design and other industrial applications. Includes eight new dispersions. (221)

Coating Resins. Barrett Div., Allied Chemical & Dye Corp., 12 pp, illus. Properties of Plaskon urea and melamine coating resins for baking enamel systems. (222)

Chromate Conversion Coatings. Allied Research Products, Inc., 4 pp, illus., No. 8. Complete data on the basic characteristics of Iridite chromate conversion coatings and their functions on various metals. (223)

Aluminum Protection. American Chemical Paint Co., 4 pp. How to protect unpainted aluminum with Alodine No. 1200, a corrosion resistant coating that provides a durable paint bond. (224)

Coated Abrasives. Armour & Co., Coated Abrasives Div., 6 pp, illus. "How to Store Coated Abrasives" shows that a constant relative humidity prevents deterioration. (225)

Ultrasonic Cleaning. Pioneer - Central Div., Bendix Aviation Corp., 8 pp, illus. Folder describes ultrasonic cleaning process and equipment. (226)

Rhodium Plating. J. Bishop & Co. Platinum Works, 5 pp. Data on the preparation of rhodium plating solutions and a stock list of noble metal salts and solutions. (227)

Hardsurfacing Alloys. Coast Metals, Inc., 6 pp. Describes alloy filled tubes in coils for automatic welding or cut to length for manual application. (228)

Enameled Metal Strip. Coated Coils Corp., 4 pp, illus. Describes coiled enameled metal strip supplied in widths up to 30 in. Strip can be put through operations without damaging the coating. (229)

Spray Painting. Conforming Matrix Corp., 5 pp, illus. Description, uses and advantages of this firm's spraying masks, mask washing machine and spray painting equipment. (230)

Aluminum Finishing. Diversey Corp., 4 pp. Lists cleaning and finishing equipment for aluminum. (231)

Degreasing Solvent. Dow Chemical Co., 6 pp, illus. Describes degreasing solvent "Chlorothene" for cold cleaning, dip cleaning and bucket cleaning operations. (232)

Solid Film Lubricants. Electrofilm, Inc., 4 pp, illus. Where Electrofilm solid film lubricants should be used and how they reduce friction and increase wear life. (233)

Paint for Metal. Glidden Co., 20 pp, illus. Displays application of Nubelite, an industrial paint finish for any metal product. (234)

Metal Cleaner. Kelite Products, Inc., 2 pp, illus., No. 17-R. Degreasing and decarburizing agent. Formula 555, for aircraft and automotive parts. (235)

Coatings, Adhesives. Magic Chemical Co. Catalog of Magic-Vulc protective coatings and Peerless industrial adhesives. (236)

Metal Cleaning. Magnus Chemical Co., Inc., 8 pp, illus., No. 704-AL. "Metal Parts Batch Cleaning in Minutes" discusses metal cleaning machines. (237)

Corrosion Prevention. Metallizing Engineering Co., Inc., 4 pp, illus. Describes Metco Systems and explains how these pure metallized zinc or aluminum coatings prevent corrosion. Typical applications shown. (238)

Colored Silicone Finishes. Midland Industrial Finishes Co., illus. An inter-

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esting discussion of the application of colored silicone finishes. (239)

Micropolishing. Murray-Way Corp. Engineering specifications and auxiliary equipment needed for micropolishing. (240)

Phosphate Coating. Neilson Chemical Co., 4 pp, illus. Process for cleaning and phosphating metal surfaces for painting. (241)

Stripper. Northwest Chemical Co., 1 p. A liquid stripper to remove organic finishes from plastics. (243)

Corrosion Proofing. Pennsylvania Salt Mfg. Co., 8 pp, illus. Corrosion proofing materials and techniques, including information on cement mortars, interliners for masonry construction, protective coatings and linings for surface treatment. (244)

Fluorocarbon Resin Coatings. Permolite, Inc., 8 pp. Fluor-O-Alloy coatings based in trifluorochloroethylene polymer. Includes corrosion resistance data and application data. (245)

Industrial Brushes. Pittsburgh Plate Glass Co., Brush Div., Dept. W-4, 3221 Frederick Ave., Baltimore, Md. Case histories indicate economies available to users of Pittsburgh brushes. Request on company letterhead.

Metal Finishing. Promat Div., Poor & Co., 4 pp, illus. Explains Pre-Galv process of controlling galvanizing operations by use of only one addition to each of the pickle and flux operations. Result is superior, controlled galvanizing, longer acid life, controlled dross formation and improved appearance. (252)

Precoated Strip. Thomas Strip Div., Pittsburgh Steel Co., 18 pp, illus. Strip steel electrolytically and hot dip coated with zinc, copper, brass, lead alloy, nickel, chromium or lacquer with or without rolled in patterns. Includes ten sample disks of coated strip. (246)

Polyvinyl Chloride Coatings. Quelcor, Inc., 4 pp, illus., No. 53A. Polyvinyl chloride coatings fused and flowed on metal for corrosion protection. (247)

Ceramic Coatings. Solar Aircraft Co., 8 pp, illus. Uses and properties of Solaramic coatings, a family of proprietary ceramic coatings designed to protect high or low alloy steel fabrications from heat and/or corrosion. (248)

Corrosion Resistant Coating. Specialty Coatings, Inc., Div. of Thompson & Co., 6 pp, illus. Examples of how Vinsynite Pretreatment was used in finishing six different types of metal products for good paint adhesion and corrosion resistance. (249)

Abrasive Materials. Sterling Grinding Wheel Co., 28 pp, No. 1-55. Catalog provides a quick way to select proper grinding wheels from factory stock. Also information for ordering custom made abrasive tooling. (250)

Paint Bond Coating. Turco Products, Inc., 4 pp. Explains benefits of Turcoating process, which puts a chemical coating on metals before painting. Other uses include antifriction coating, rust removal, cleaning and passivation. (251)

Methods & Equipment

Induction Furnaces. Ajax Electrothermic Corp., 8 pp, illus., No. 27-B. Induction furnaces for precision melting, heating forging billets and heat treating. Includes selector chart for induction heating and melting applications. (257)

Precision Inspection Instrument. American Cystoscope Makers, Inc. Features and typical uses of ACMI borescopes for precision inspection. (258)

Heat Treating Equipment. American Gas Furnace Co., 140 Spring St., Elizabeth, N. J., 24 pp, illus., No. C-1304. Blow pipes, forges, pot furnaces, brazing and industrial heating machines. Request from American Gas on company letterhead.

Testing Machine. Baldwin-Lima-Hamilton Corp., 12 pp, illus., No. 4401. Hydraulic machines with capacities from 10,000 to 5,000,000 lb are described, including standard and special types of vertical and horizontal machines. (259)

Echelle Spectrographs. Bausch & Lomb, 23 pp, illus. Catalog shows how the echelle type spectrograph works, what it does and its instrumentation. (260)

Sintering Furnaces. Drever Co., 12 pp, illus., No. B-101. Describes furnaces for sintering metal powder products. (261)

Explosive Rivets. E. I. du Pont de Nemours & Co., Inc., Explosives Dept., 32 pp, illus., No. A-2281. Complete data on two types of explosive rivets—high speed industrial explosive rivets and aircraft explosive rivets. Specifications and installation procedures are included. (262)

Welding Materials. Eutectic Welding Alloys Corp., 140 pp, illus., No. TIS 2575. Pocket data book featuring simplified welding procedures for all base metals. Covers 120 welding rods, electrodes, welding compounds. (283)

Reducing Atmosphere Generators. Gas Atmospheres, Inc., 4 pp, illus., No. R-352. Atmosphere generators for industrial applications such as bright hardening, annealing, gas carburizing and sintering. (263)

Acid Corrosion Inhibitor. General Aniline & Film Corp., Antara Chemicals Div., 6 pp, No. TA-17. Data on Propargyl alcohol, an inhibitor that prevents strong mineral acids from attacking ferrous metals. (282)

Temperature Controls. Claude S. Gordon Co., 4 pp, illus. Brief description and advantages of a straight line, fully automatic temperature control. (264)

Lock Washers. Hobbs Mfg. Co., 4 pp, illus., No. 255. Shows a complete line of Tangle-Proof high carbon steel, stainless steel and silicon and phosphor bronze lock washers. (265)

Heat Treating. Holcroft & Co., 12 pp, illus. Information on various types of Holcroft furnaces. (266)

Die Casting Lubricants. E. F. Houghton & Co., 4 pp, illus. Outlines development of die casting lubricants to meet modern high production needs. (267)

Pyrometers. Illinois Testing Labs, Inc., 6 pp, illus. Thermoelectric pyrometer for precision measurements of temperatures beyond 1000 F. (268)

Tablet Presses. Kux Machine Co., 4 pp, illus. Tabletting presses for production of powdered metal parts, ceramic parts and explosives. (269)

Die Casting Machines. Lester Phoenix, Inc. Features and specifications of die casting machines and injection molding machines. (270)

Welding Aluminum Sheet. Linde Air Products Co., 1 p, No. 54-6R. Instructions for oxyacetylene welding of aluminum sheet. (191)

Radiography. Metal & Thermit Corp., 4 pp, illus. Industrial radiography with gamma rays for field and shop work. (271)

Furnace and Oven Controls. Minneapolis-Honeywell Regulator Co., 44 pp, illus., No. 54-1. Catalog and price list on Brown instruments and Honeywell controls for industrial furnace and oven equipment. (272)

Cathodic Protection. National Carbon Co., 12 pp, illus., No. S-6500. How to mitigate corrosion of underground and submerged metal structures by application of an impressed current cathodic protection system using graphite anodes. (273)

Flame Hardening. National Forge & Ordnance Co., 4 pp, illus. Advantages gained by flame hardening large forgings. (274)

Hole Quencher. Palmer Mfg. Co., 4 pp, illus. Features benefits of using the I. D. Hole-Quencher for case hardening holes seven times faster. (275)

Electric Furnaces. Pereny Equipment Co., 3 pp, illus., No. 4A. Advantages and illustrations of typical electric furnaces and kilns. (276)

Set Screws. Set Screw & Mfg. Co., 24 pp, No. 19. Lists prices and dimensional information. (277)

Preheat Temperatures. Tempil Corp. Chart lists recommended preheat temperatures for 79 commonly used metals and alloys. (278)

Weldbrazing. Uniworld Research Corp. of America, 4 pp, illus. Special steel filler alloys combine fusion welding and brazing process. This process is applicable to all types of gas and electric welding with standard welding equipment. (279)

Heat Treating Furnaces. Waltz Furnace Co., illus. Describes types of industrial furnaces for heat treating, enameling, cyaniding and annealing in controlled and regular atmospheres. (280)

Heat Treating Furnaces. Westinghouse Electric Corp., Industrial Heating Dept., 38 pp, illus., No. B-5459. Complete description of Westinghouse furnaces—large and small, gas and electric. (281)

To obtain literature listed on these pages, use the convenient prepaid post card on pp 69 and 70.

One Point of View:

Engineers: labor or management ... or neither?

The status of the rank and file engineer is hanging in the balance. The next few years will probably determine whether he will continue as a professional man or whether he will align himself with labor and be relegated to the skilled labor class.

The Engineers Joint Council has just issued a report on the subject titled, "Raising Professional Standards and Improving Employment Conditions for Engineers." Although the report does serve to again focus attention on the causes for the trend toward collective bargaining by engineers, it fails to deal with the central problem of finding an effective way to look after the engineer's professional and economic needs.

Let's be realistic

For many years engineers were an integral part of management. But to assume, as the EJC report does, that nonsupervisory engineers are still part of management or that management protects their interests is not realistic. Although in the large modern industrial organization engineering is closely allied to management, it is, nevertheless, a distinct and separate function. The separation between the two has been further aggravated during the last decade or so by management's failure to maintain a comparatively high professional and economic level for engineers. For example, in many cases there is now little difference in salary between rank and file engineers and members of the skilled trades, or between experienced and starting engineers. Also, there has been inadequate recognition of engineers as professional employees, often resulting in the assignment of engineers to subprofessional work.

Unionize engineers?

While the gap between management and the working engineer has been widening, the engineering profession has failed to take steps to bolster its own professional and economic status. The engineering societies have proved to be constitutionally inadequate for that purpose, and national professional engineering organizations have failed to obtain the degree of support necessary to take effective action.

Meanwhile, growing numbers of engineers have turned to unions. Although the number of engineers actually in unions is still small, findings of a survey made by the Engineers Joint Council would seem to indicate that about 25% of the engineering profession is not opposed to collective bargaining for engineers.

Action needed

If engineers are to retain their identity as members of an independent professional group, either an existing or a new national professional engineering organization will have to actively assume the responsibility for engineers' economic and professional status. To be successful, such an organization would need the wholehearted support of all the engineering societies. Unfortunately, there is still wide divergence of opinion among various groups on a unified course of action. The future of the engineering profession may well depend upon how quickly and how effectively these differences are resolved.

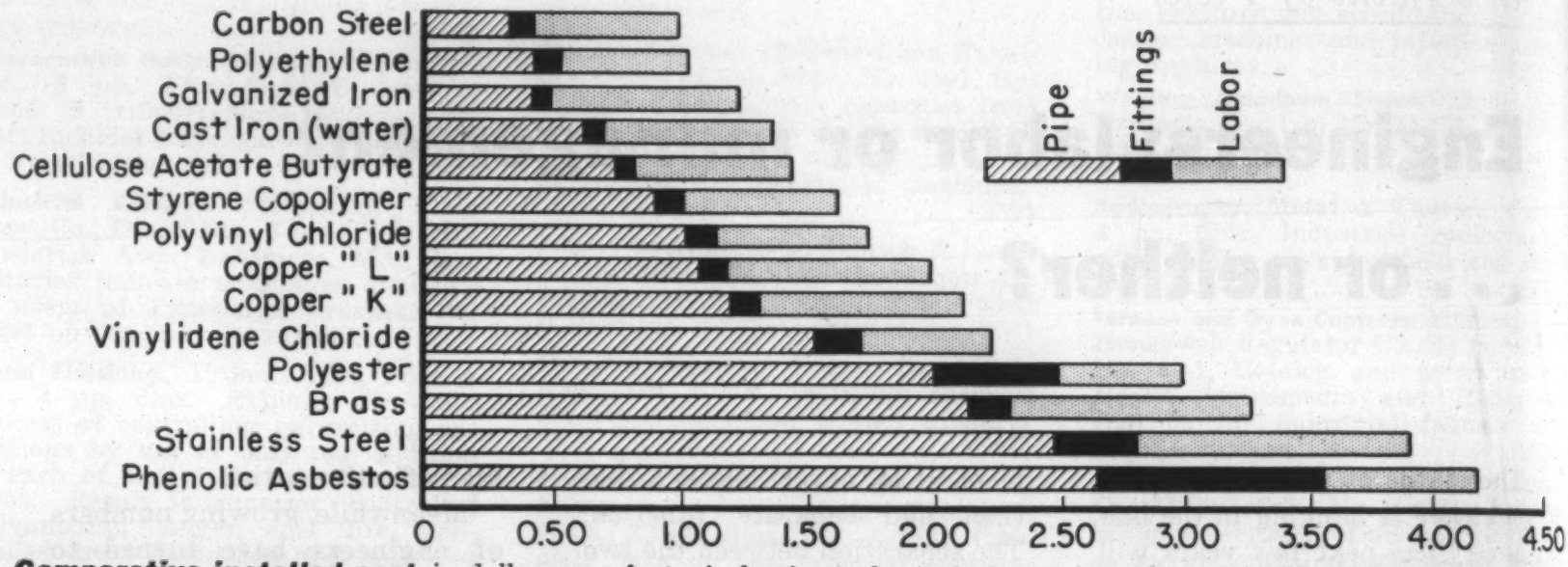
Plastics Pipe

How six major types compare with metal pipe...

...in cost

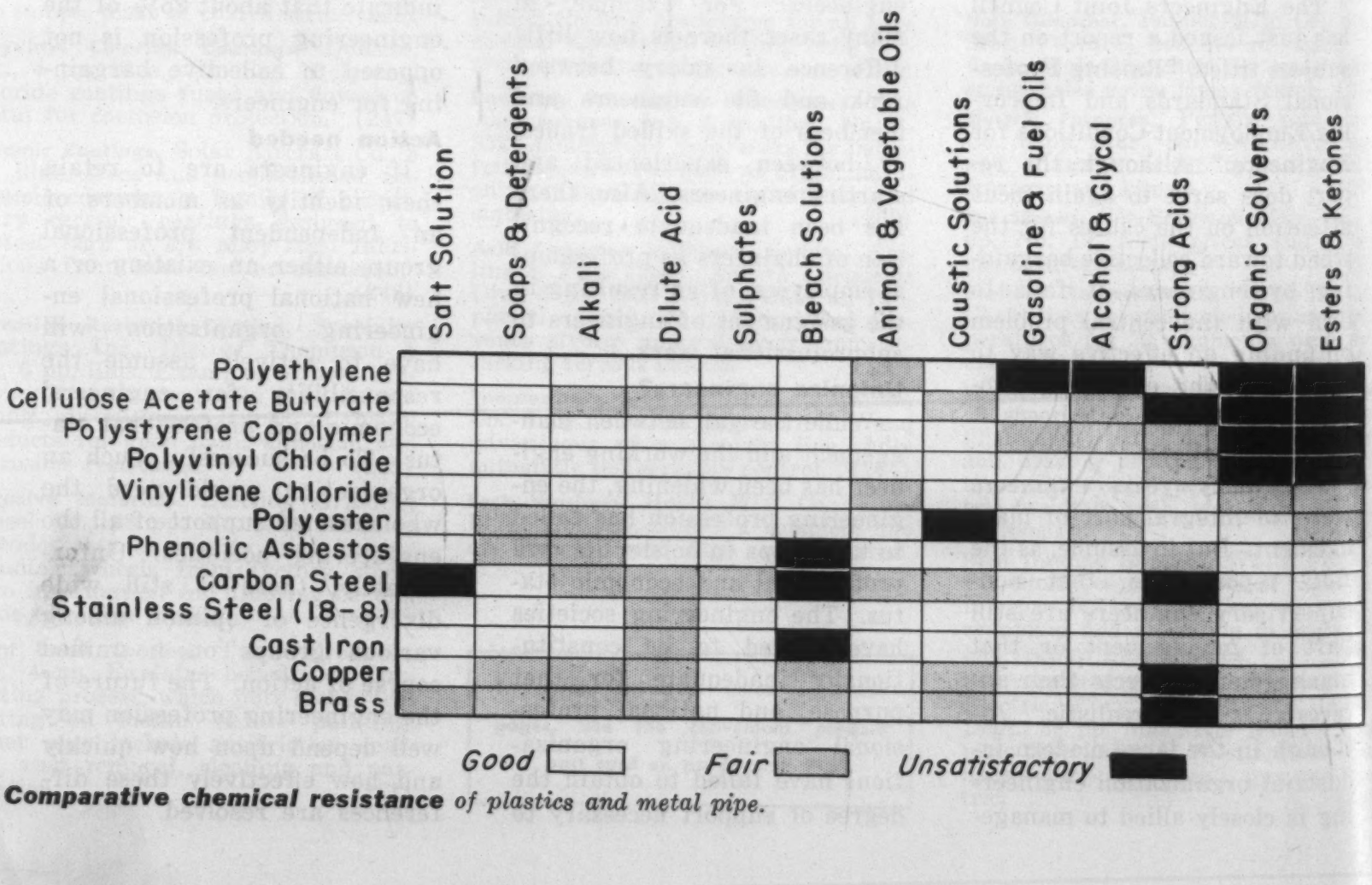
by R. T. Bogan,
Plastics Div.,
Monsanto Chemical Co.

■ Pipe is now a major application for plastics materials. In general, plastics pipe has the following advantages over metal pipe for the user: 1) resistance to water, chemical and electrolytic attack; 2) light weight and flexibility,



Comparative installed cost *in dollars per foot of plastics and metal pipe (2 in. pipe and 8 fittings per 100 ft).*

...in chemical resistance



Comparative chemical resistance *of plastics and metal pipe.*

resulting in ease and economy of installation and simplified handling of long lengths; 3) minimal solid deposit collection, resulting in low frictional losses and turbulence of flow.

Major limitations of plastics pipe compared with metal are 1) poor temperature resistance and dimensional stability, and 2) high cost due to basic resin and conversion costs, plus high market development expenses.

Materials

Plastics pipe is being produced in sizeable quantities in this country in six types of plastics: polyethylene, polyvinyl chloride, vinylidene chloride, cellulose acetate butyrate, styrene copolymers, and reinforced polyester resins. In addition to the general advantages and limitations of plastics pipe as mentioned above, each of the materials has properties which make it suitable for specific types of applications.

Polyethylene—Between 80 and 90% of plastics pipe sold is made

Eastman Chemical Products, Inc.

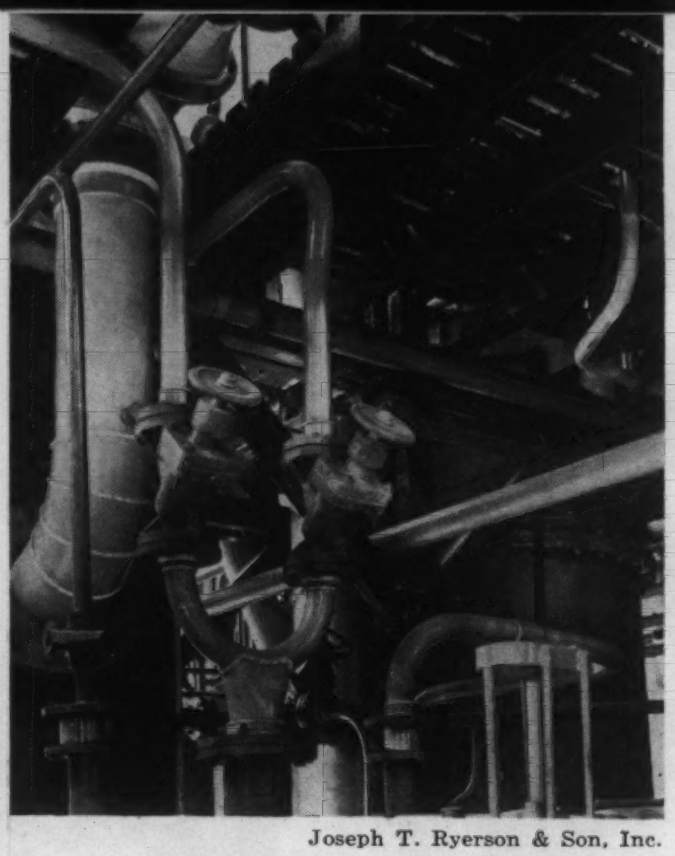
Cellulose acetate butyrate *pipe shown here delivers about 40% more fluid than clean steel pipe of the same diameter. It is being used for sour crude oil and salt water disposal lines.*

...*in typical properties*

TABLE 1—TYPICAL PROPERTIES OF PIPE MATERIALS

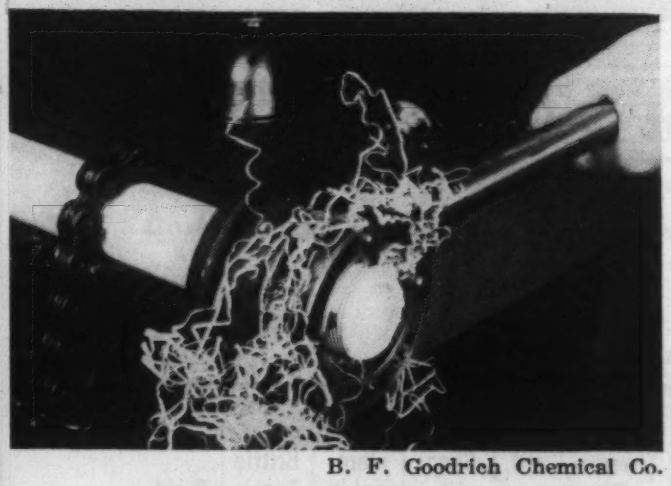
	Spec. Gravity	Max Ten Str, 1000 psi	Flex Str, 1000 psi	Impact Str (Izod Notched) ft-lb/in.	Mod of Elast, 10,000 psi	Comp Str, 1000 psi	Operating Temp Range or Max, F	Coeff of Exp, 10^{-5} in./in./F	Heat Dist (66 psi) F	Thermal Cond, Btu/hr/sq ft/F	Spec Ht, cal/gm/C	Flammability	Brittle Temp, F	Rigidity
Polyethylene	0.92	1.4-2.5	1.7	32	2	—	−70 to 160	16-32	120	2.3	0.55	Burns	−90	Flex
Polystryene Copolymer	1.07	6	6-9	5.0	2.3	12 to 16	170	3.4	—	1.0	0.32	Slow	−80	Rigid
Polyvinyl Chloride	1.4	9	10	0.2-18	5	8 to 12	158	4.4	165	2.4×10^{4}	0.24	Self-Ext	0	Rigid
Polyester (Glass Fiber Reinforced)	1.8	41	38	15-34	20	40	−60 to 275	4.0	300	1 to 5	0.25	Slow	—	Rigid
Phenolic Asbestos	1.7	2.25-4.5	6.5	0.476	—	11	265	1.8	—	0.2	0.30	Self-Ext	—	Rigid
Cellulose Acetate Butyrate	1.2	6.7	4.9-7	1.5-6	1.4	5 to 7	150	6-9.4	—	$3.22\text{-}6.45 \times 10^{-4}$	0.35	Slow	—	Rigid
Vinylidene Chloride	1.75	4-8	6	0.3-8	0.8	8	175	28.4	160	1.77×10^{-4}	0.32	Self-Ext	—	Semi-Flex
Carbon Steel (Sched. 40)	7.8	48	—	(=)	—	—	−200 to 1000	0.6	—	26	—	—	—	Rigid
Stainless Steel (18-8, Sched. 5)	8.0	75	—	(=)	—	—	−200 to 1200	0.9	—	15	—	—	—	Rigid
Cast Iron	7.2	21	—	(=)	8	—	—	0.6	—	30	0.11	—	—	Rigid
Copper	8.9	35	—	—	—	—	—	1.0	—	197	0.09	—	—	Rigid
Brass	8.6	40	—	—	—	—	—	1.0	—	92	—	—	—	Rigid

Table 1—*Comparison of typical properties of metal and plastics pipe.*



Joseph T. Ryerson & Son, Inc.

Rigid polyvinyl chloride *pipe is shown installed in a chlorine drying and liquefaction plant to carry both dry and moist chlorine gas. Valves are also of PVC.*



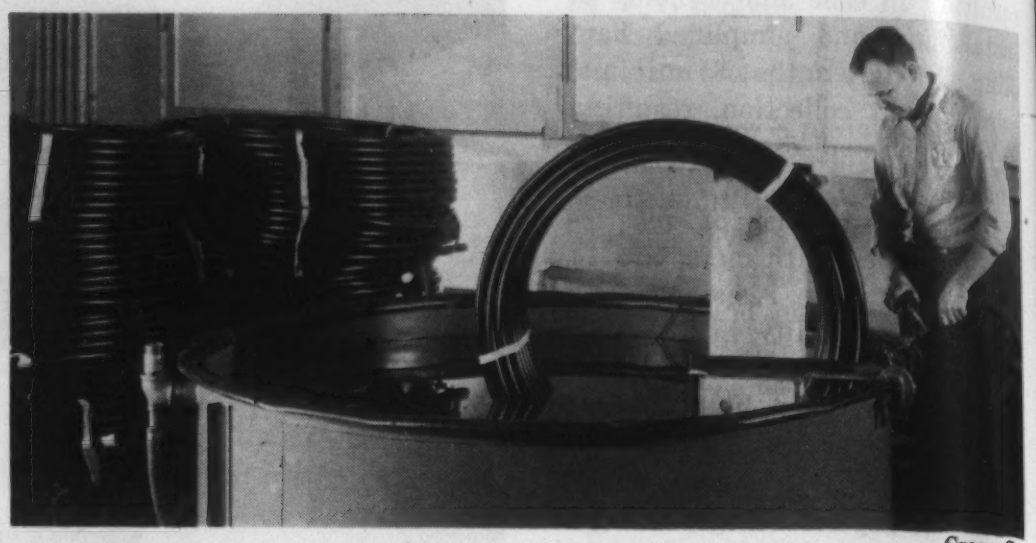
B. F. Goodrich Chemical Co.

Standard threading procedures *can be used with rigid polyvinyl chloride pipe.*

of polyethylene. Pipe is very flexible in thin sections, but becomes stiffer as wall thickness is increased.

Specifically, polyethylene has the following advantages in use, as compared with metal: 1) lightest of plastics resins used for pipe; 2) controlled flexibility; 3) ease of manufacture; and 4) low cost.

Its major limitations are: 1) low softening point limiting service temperature; 2) relatively low strength so that low working pressures must be used; 3) since polyethylene is dissolved by hydrocarbons, it is useless for petroleum service; 4) low abrasion resistance; 5) ignites slowly and burns; and 6) is degraded by



Crane Co.

Polyethylene *pipe quality is controlled by air pressure testing in water.*

ultraviolet light.

Cellulose acetate butyrate—Approximately 6% of plastics pipe is made of cellulose acetate butyrate. The resin formula can be altered to produce pipe with hardness ranging from flexible to extremely hard and brittle.

Specific advantages as compared with metal are: 1) excellent resistance to weathering and sunlight; 2) flexibility of resin formulations to provide range of properties; 3) transparency; and 4) reasonable cost.

Limitations of the material for pipe are: 1) requires low operating pressures and temperatures; 2) is not impervious to artificial gas, and cannot be used with strong acids, alkalies or organic solvents; and 3) becomes brittle at low temperatures.

Styrene copolymers—High impact styrene resins are copolymers of styrene-butadiene and acrylonitrile and comprise approximately 6% of the plastics pipe market. Styrene copolymer pipe can be used for the same applications as cellulose acetate butyrate but it does not have the low temperature brittleness of butyrate. In addition to good low temperature flexibility, the copolymers have good corrosion resistance, particularly to chlorine-containing compounds. Major limitations are requirements for low working pressures and operating temperatures.

Rigid (unplasticized) polyvinyl chloride—Though rigid polyvinyl chloride is one of the newest plastics to enter the plastics pipe picture in this country, it possibly has the greatest potential of the thermoplastic resins.

Its specific advantages are: 1) high impact strength; 2) highest tensile strength of the thermoplastic resins; 3) wide operating temperature range; 4) good dimensional stability; 5) good weathering properties; and 6) excellent resistance to oxidizing agents like sodium hypochlorite, to chlorides, and to several of the strong acids.

Its major limitations are: 1) difficulty in extruding uniform walls and smooth surfaces; 2) higher weight (50% heavier than polyethylene); 3) high cost; and 4) poor resistance to many organic solvents.

Vinylidene chloride (Saran)—Though one of the first materials used to make plastics pipe, vinylidene chloride has been supplanted as a structural pipe material by more desirable plastics. It is now primarily used as a lining for metal pipe. Its major advantage is good corrosion resistance, especially to salt solution and dilute acid and caustic solutions.

Major limitations are: 1) tendency to cold flow; 2) brittleness at low temperature; 3) high cost; and 4) lack of corrosion resistance to strong alkalies, and aromatic and chlorinated solvents.

Polyester (glass fiber reinforced)—Glass-reinforced polyester pipe permits the highest work-

ing pressure and operating temperature specifications of all major types of plastics pipe.

Primary advantages include: 1) high tensile strength, permitting high working pressures; 2) high strength-to-weight ratio; 3) wide operating temperature range; and 4) no cold flow.

Major limitations are: 1) high cost; 2) lack of resistance to strong alkalies; 3) reduction in strength after continued immersion in water; and 4) erosion which can result in loss of fiber reinforcement.

Phenolic-asbestos—This type of pipe has good resistance to elevated temperatures, but has relatively low strength. It resists corrosive attack by a wide variety of materials, but is relatively high in cost, and due to its low strength, can be subjected only to low working pressures.

Other types — Glass-reinforced epoxy pipe is growing in use. It is more expensive than polyester, but its better strength, dimensional stability and chemical resistance promise that eventually it may supplant polyester for high pressure pipe applications. Its major disadvantage is its relatively poor resistance to elevated temperatures.

Fluorocarbon plastics, tetrafluoroethylene and monochlorotrifluoroethylene, are used in pipe form to carry concentrated acids and caustics at temperatures up to around 400 F. High materials costs would seem to prohibit their use for any pipes but those operating under extremes of temperature and corrosive conditions.

Nylon is being used in specialty applications. Certain types of nylon tubing have been prepared with a rated burst pressure of 2500 psi. Material cost is probably too high for large scale commercial pipe installations.

Methyl methacrylate is being used for special applications where visual observation of fluid flow is necessary.

Mechanical properties

Properties of plastics pipe depend on the resin and formulation used, as well as on the diameter, wall thickness and temperature of fluid being transported. Table 1 gives reasonable comparative properties for pipe made of the various materials.

Caution must be practiced in application of plastics pipe where

How to Figure Costs

A system has been devised whereby a quick estimate can be made of comparative plastic and metal installed costs using one and two inch pipe. The system uses a conversion factor based on actual contractors' bids on plumbing jobs in which either plastics or metal pipe could have been used. It should be pointed out that labor costs for installing plastics pipe were found to be 50% higher than those for installing metal pipe. In time this higher cost will be reduced when plastics pipe is universally accepted by the plumbing industry.

In order to use the conversion table shown, the unit cost per foot of plastic or metal pipe is required. Multiplying this cost by the "p" factor gives the installed cost.

CONVERSION FACTORS

	1 Inch Pipe		2 Inch Pipe		Average Ratio "P-Factor"
	Pipe Cost, $/Ft	Ratio Installed Pipe Cost	Pipe Cost, $/Ft	Ratio Installed Pipe Cost	
Polyethylene (General Purpose)	0.20	2.4	0.45	2.3	2.35
Cellulose Acetate Butyrate	0.22	2.5	0.74	1.9	2.2
Polystryrene Copolymer	0.39	2.0	0.90	1.8	1.9
Polyvinyl Chloride	0.46	2.0	0.98	1.8	1.9
Vinylidene Chloride	0.78	1.5	1.56	1.5	1.5
Polyester	—	—	2.00	1.5	1.5
Phenolic Asbestos	1.68	1.6	2.64	1.6	1.6
Carbon Steel	0.17	2.8	0.34	2.9	2.85
Galvanized Iron	0.20	2.8	0.42	2.8	2.8
Cast Iron	—	—	0.63	2.2	2.2
Copper L	0.41	2.2	1.06	1.9	2.0
Copper K	—	—	1.19	1.8	1.8
Brass	0.96	1.4	2.16	1.4	1.4
Stainless Steel	1.84	1.4	2.47	1.6	1.5

TABLE 2—WORKING PRESSURES AND TEMPERATURES

	Allow. Working Pressure at 75 F, psi	Max Ten Str, psi	Max Working Temp, F	Allow. Pressure at Max Working Temp, psi
Carbon steel	850	48,000[a]	650	500
Polyethylene	75	2,500[a]	160	25
Galvanized iron	850	48,000[a]	650	500
Cast iron	150	21,000	300	150
Cellulose acetate butyrate	100	6,700[b]	150	65
Polystyrene copolymer	165	6,000[a]	170	60
Polyvinyl chloride	156	9,000[a]	180	55
Copper L	300	35,000	406	198
Copper K	400	35,000	406	235
Vinylidene chloride	125	8,000[c]	175	50
Polyester	600	41,000	275	120
Brass	400	40,000[a]	406	394
Stainless steel	820	75,000[d]	650	725
Phenolic asbestos	65	4,500	265	65

[a] *Schedule 40* [b] *Solvent Welded Pipe* [c] *A.S.A. Schedule 80* [d] *Schedule 5*

temperature and pressure are factors. For example, a maximum working pressure of 170 psi can be used in small diameter polyethylene pipe at below zero temperatures. Yet polyethylene at 160 F has a recommended working pressure of only 25 psi. Vinylidene chloride has a maximum operating temperature of 175 F, but a working pressure at this temperature of only 50 psi. Butyrate, PVC and styrene types have more favorable pressure-temperature relationships. Table 2 shows typical pressure-temperature relationships for pipe materials. Allowable working pressure of thermoplastic pipe varies inversely with temperature.

Thermosetting resin type pipes can safely withstand another 100 degrees of temperature, or 275 F, but are extremely brittle and have low pressure limitations unless reinforced with glass mat or cloth. Reinforced polyester pipe can safely withstand a pressure of 120 psi at a temperature of 275 F.

When a time factor is introduced in addition to pressure and temperature, problems are compounded. A great deal of work has been done in developing an understanding of time-dependent properties, both of thermoplastic and reinforced thermosetting plastics. But currently, relatively little definitive data are available. Long range serviceability of plastics pipe under both static pressure and dynamic loading is currently being studied as part of an SPI-sponsored project at Battelle Memorial Institute, but to date only results of empirical testing plus a generous safety factor can be used as a guide to materials selection and design of pipe.

TABLE 3—CURRENT STANDARD DESIGN AND CALCULATED DESIGN FOR 300 PSI SERVICE

Pipe Material	Present-Day Practice					Calculated for 300 Psi Service		
	Std O. D. of Pipe, in.	I.D., in.	Wall Thick., in.	Wt. of Pipe/ Lin. Ft, lbs.	Work. Press., psi	I. D. of Pipe, in.	Wall Thick., in.	Wt of Pipe/ Lin. Ft, lbs.
Carbon steel (Sch. 40)	2.375	2.067	0.154	3.66	850	2.067	—	3.66
Polyethylene	2.375	2.067	0.154	.44	75	1.135	0.62	1.36
Galvanized iron	2.375	2.067	0.154	3.66	850	2.067	—	3.66
Cellulose acetate butyrate	2.250	2.00	0.125	0.45	100	1.5	0.375	1.15
Polystryene copolymers	2.375	2.067	0.154	0.51	165	1.817	0.279	0.85
Polyvinyl chloride	2.375	2.067	0.154	0.624	156	1.781	0.297	1.18
Copper L	2.125	1.985	0.070	1.75	300	1.985	0.070	1.75
Copper K	2.125	1.959	0.083	2.06	400	1.959	—	2.06
Vinylidene chloride	2.375	1.939	0.218	1.09	125	1.327	0.524	2.308
Polyester	—	—	0.50	3.06	600	—	—	—
Brass	2.375	2.063	0.156	4.12	400	2.062	—	4.12
Stainless steel	2.375	2.310	0.065	1.604	820	2.310	—	1.60
Phenolic asbestos	3.00	2.00	0.50	2.89	65	—	—	—

TABLE 4—SIZES AND FABRICATION

Pipe Material	Joint Method	Sizes, in.	Length, ft
Polyethylene	Slip sleeve & bond, heat weld, threaded	0.25 to 6	Coils to 500
Polystyrene copolymer	Threaded, flanged	0.5 to 6	10, 21
Polyvinyl chloride	Threaded, slip sleeve & bond, heat welded	0.5 to 15	4, 10, 20
Polyester: (glass fiber reinforced)	Threaded, flanged, slip sleeve & bond	0.25 to 12	
Phenolic asbestos	Threaded, flanged	0.5 to 12	4, 10
Cellulose acetate butyrate	Threaded, flanged, solvent weld, extruded sleeve	0.5 to 6	500 coils 20, 30
Vinylidene chloride	Threaded, flanged heat weld	0.125 to 4	10, 25
Carbon steel	Threaded, flanged, welded		21
Stainless steel (18-8)	Threaded, flanged, welded		21
Cast iron	Oakum & lead	3 to 60	12, 20
Copper	Sweat & solder	.125	6, 20
Brass	Threaded, flanged		6, 20

Design considerations

Allowable working pressures for metal pipe can be calculated by using Barlow's equation for thin wall hollow cylinders under tension:

$$Pw = \frac{2t\ Sw}{D}$$

Where:

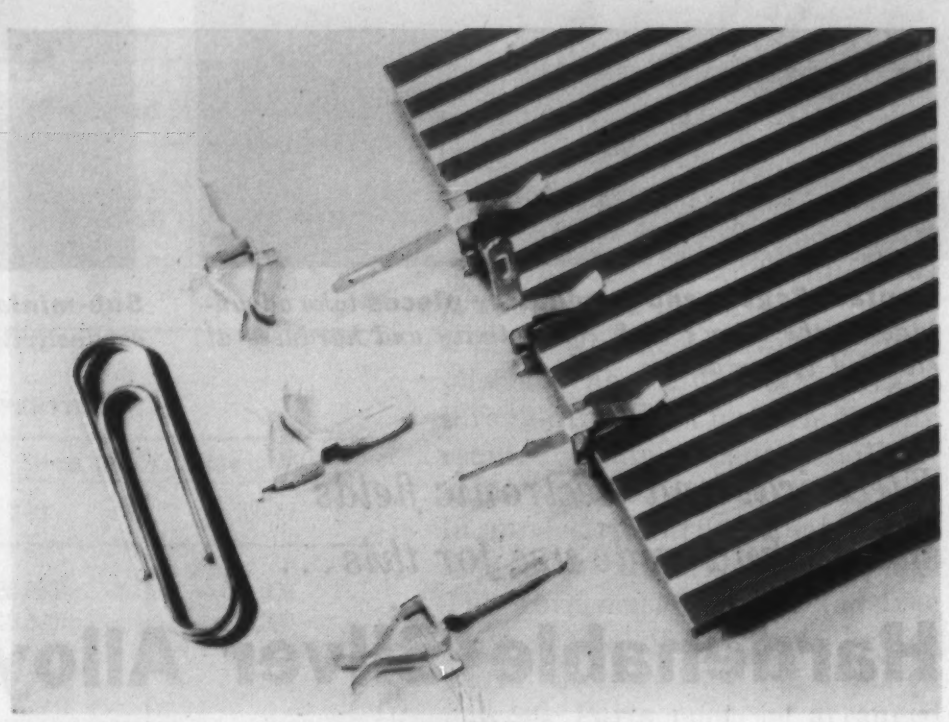
Pw = Allowable working pressure, psi
t = Thickness of pipe wall, in.
D = Outside diameter, in.
Sw = Working tensile strength, or 1/5 of maximum tensile strength, psi.

This equation does not exactly apply to plastics since creep rate under stress is much higher in plastics than in metals. Theoretical wall thicknesses of plastics pipe, based on Barlow's equation, have been calculated in order to study the effect of designing for high pressure service while maintaining o.d.'s established as standards for metal pipe. Table 3 shows results of these calculations for a working pressure of 300 psi holding to the 2 in. o.d. metal pipe standard. The figures highlight the increase in wall thickness necessary when thermoplastic pipe is designed to withstand high pressures under dimensional limitations. In most cases it is impracticable to increase wall thickness enough to be competitive with metal pipe in mechanical strength or in available internal open area.

Another design limitation of plastics pipe is notch sensitivity. A cut thread or deep scratch will weaken some plastics so that under sudden stress the pipe will fail at the notch or cut. This limitation causes fitting and threading problems when working with some materials for some specific applications.

Tungsten carbide for minute parts

For tiny, hard parts such as those used in guided missiles, instruments or as bearings for aircraft components, tungsten carbide is often preferred. It holds its size because it does not expand and contract as other materials do. Van Keuren Co. makes these tiny pivots about 0.030 in. in dia. and 0.165 in. in length. The square ends are lapped and so highly polished that they look black. Most of the carbide is supplied by the General Electric Carboloy Dept.



Beryllium copper contacts increase connector life

Different styles of beryllium copper contacts are compared to a paper clip for scale. Contacts mounted on sample printed circuit card show how contact is made with copper foil circuit. Beryllium copper contact is in the form of U-shaped strip that grips the card.

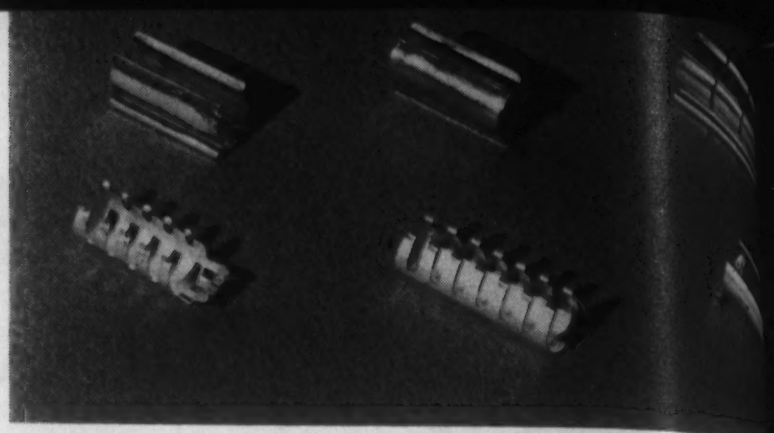
Last year H. H. Buggie, Inc., used more than 6,000,000 beryllium copper contacts in connectors that found application in television, radio, radar, guided missiles and other equipment. Berylco 25 alloy strip, 0.015 or 0.022 in. thick is material employed. Made by Beryllium Corp., it has a nominal chemical composition of Be 1.80-2.05, Co 0.20-0.30%, Cu balance. Alloy has high strength, good electrical conductivity, long fatigue life and excellent resistance.

MATERIALS AT WORK

Stainless steel solves spring problem

Stacker springs for IBM high speed sorter stackers are critical parts demanding zero initial tension, deflection at a constant rate and maintenance of close tolerances on load variations. After experimental work by John Evans Sons, Armco 17-7 PH stainless steel was selected because it provided the critical characteristics at an economical cost. With other materials zero tension could be obtained only by winding the spring with space between the coils, or by hand-setting each spring. The former method presented tolerance problems, the latter was time-consuming. Beryllium copper springs met the requirements, but cost much more than stainless. The 17-7 spring is formed in the same way as a standard extension spring. After forming, a 1-hr heat treatment at 1100 F relieves forming stresses.

Contact fingers and conducting pieces *take advantage of the alloy's high conductivity and hardness at elevated temperatures.*



Sub-miniature tube shields *require excellent thermal conductivity.*

Electrical and electronic fields should find wide use for this...

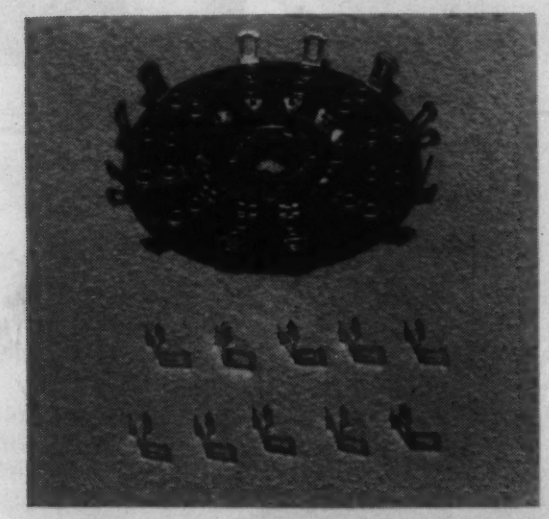
Hardenable Silver Alloy

Irreversible hardening of this recently developed silver-magnesium-nickel alloy provides high hardness and low creep rate at elevated temperatures.

by Winthrop Warren, *Metallurgist, Handy & Harman*

■ Addition of small quantities of magnesium and nickel to silver yields an alloy having unique hardening characteristics. Parts can be produced from soft material that is as readily worked as fine silver. After shaping to the final form, irreversible hardening accompanied by a considerable increase in strength is accomplished by heating in air.

Parts hardened in this manner can be soft soldered or brazed with silver brazing alloys without affecting the temper. In the hardened condition, the alloy has fair spring properties, high electrical and thermal conductivity and corrosion resistance comparable with that of fine silver.



Terminals for rotary switches *are typical applications of the alloy.*

Nominal composition of the standard silver-magnesium-nickel alloy is 99.50 silver, 0.30 magnesium and 0.20% nickel.

The alloy is available in the form of as-rolled and annealed strip down to thin gages, wire and hard drawn rod. Tubing is obtainable also on special order.

Properties

Properties of this alloy are given in accompanying tables. In the annealed condition, the tensile strength is similar to that of fine silver but the elongation is slightly lower. The two materials are strengthened roughly to the same degree by cold working. In the oxidation hardened condition, the new alloy has room temperature properties similar to those of hard rolled coin or sterling silver. Effect of composition in the properties of the oxidation hardened material is shown in a graph.

Because hardening results from an irreversible change in composition, the new alloy cannot be softened after heat treatment. As shown in the table on elevated temperature properties, strength in the air hardened condition at 500 F is comparable with that of work hardened material at room temperature. However, ductility at elevated temperatures is reduced and the material tends to fracture rather than creep under stresses higher than the stress rupture values indicated. For this reason, special attention must be given to designing for proper stresses. After parts are made and hardened, they will not accommodate design errors by plastic yielding as more ductile materials do.

The most interesting physical property of the new alloy is its high electrical conductivity. After oxidizing, it has a conductivity of 75% IACS, a value that compares favorably with that of chromium-copper, best in this respect of the hardenable copper alloys. Conductivity at 500 F is 50% IACS.

In the oxidized condition, the surface of silver-magnesium-nickel is more resistant to galling than fine silver.

The corrosion resistance of the silver-magnesium-nickel alloy is similar in general to that of fine silver. Like fine silver, it is attacked by sulfur-bearing compounds and sulfur-contaminated atmospheres.

Forming

The silver-magnesium-nickel alloy can be formed readily by deep drawing, spinning, eyeletting, bending and other conventional processes. Most parts can be produced without intermediate anneals, but work hardening induced by multiple drawing operations can be relieved by annealing, if necessary, before final forming. Hardening must be done after all forming is completed to prevent damage to the surface.

PROPERTIES OF SILVER-MAGNESIUM-NICKEL

Property	Annealed	50% Cold Worked	Air Hardened
rdness, Rockwell	60-65 (15T)	50-60 (30T)	66.5-69.5 (30T)
timate Strength, psi	28,000-34,000	50,000-55,000	65,500-68,500
ngation, % in 2 in.	30-40	6-8	5-15
ectrical Conductivity, (% IACS)	75	70	75

ELEVATED TEMPERATURE PROPERTIES

Temperature, F	Ultimate Strength (short time test), psi	Stress, psi, to rupture in:	
		2 hr	100 hr
500	45,000-55,000	30,000	22,000
750		19,000	14,000
800	35,000-45,500		
1000		9000	6000
1200	12,000-20,000		
1400	10,000-14,000		
1500		1000	800

Heat treatment

If it is necessary to soften the material for further working, it can be annealed in air providing the temperature does not exceed 700 F. Effective softening can be obtained in 15 to 30 min. Annealing at temperatures above 700 F must be done in protective atmospheres such as cracked ammonia to prevent hardening that occurs if this alloy is heated in air above 700 F.

The silver-magnesium-nickel alloy is hardened by a process of selective oxidation. This is accomplished commercially by heating the material, after all forming operations are completed, in an oxidizing atmosphere preferably at 1350 F for a period that is proportional to the thickness of the material. Hardening at this temperature yields the best combination of strength and ductility. To save time on parts that are not to be subjected to stress while hot, an oxidation temperature of 1475 F can be used. The material cannot be softened after the oxidizing process is completed. The relationship between time and temperature for a given thickness is shown in a graph.

Since hardening is accomplished by diffusing oxygen through the alloy, uniform results require certain precautions. Hardening should be done preferably in an electric furnace that can be held at a uniform temperature. The work must be clean and free from traces of lubricant, which might interfere with the diffusion process. Parts must be arranged in the furnace to permit free circulation of air.

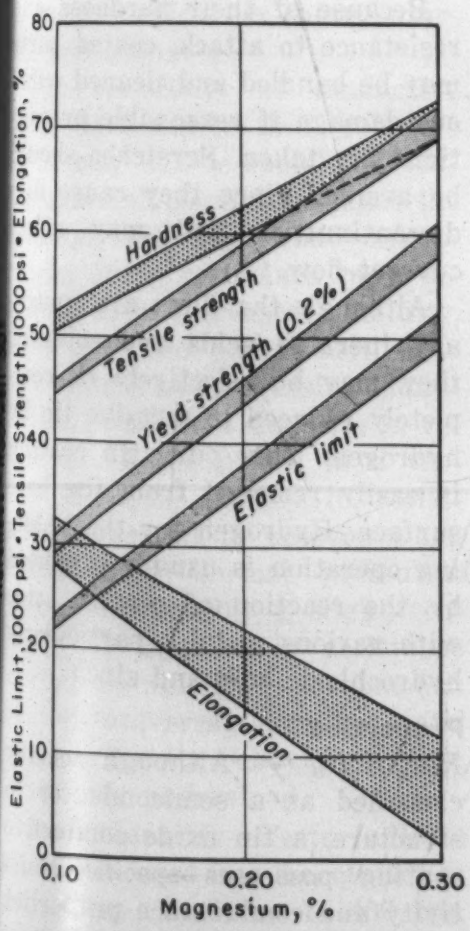
Joining

After hardening, parts can be readily joined by soft soldering or by silver brazing, using any of the standard alloys. An active flux, such as Handy Flux, is required to promote flow during brazing. Either torch or furnace heating can be used. Hydrogen furnace brazing of the hardened alloy is not feasible since the metal is embrittled if heated in hydrogen.

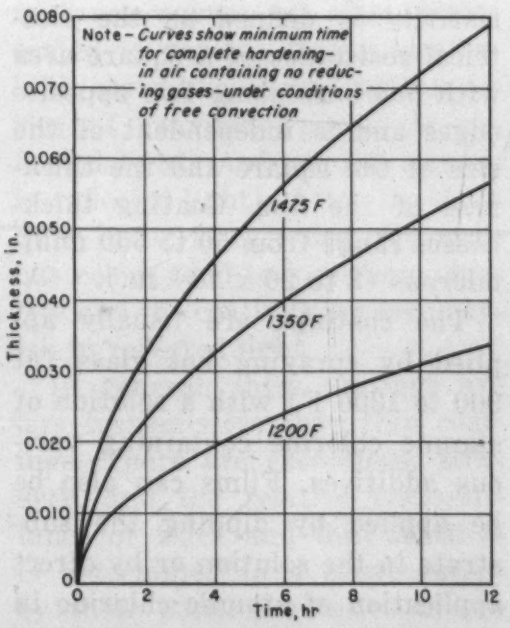
Applications

The silver-magnesium-nickel alloy can be used in many electrical and electronic applications. In certain instances, selective hardening can be used to improve the operation of the part. For example, coaxial cable connectors, having a heavy cross section at one end and a smaller cross section in the spring arms and fingers, can be hardened for a period selected to completely harden the spring end but leave the heavy end only partly hardened.

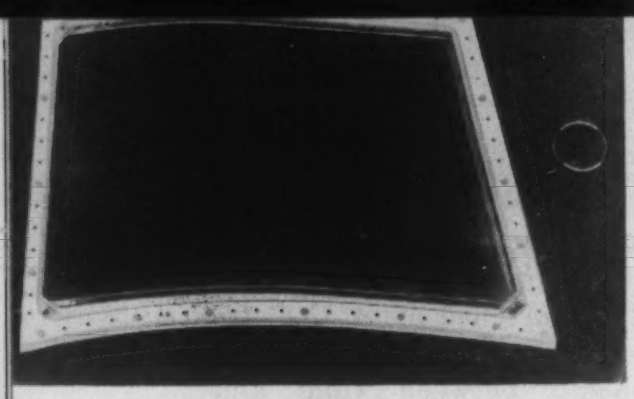
Other applications include electrical contacts, contact arms, sliding contacts and wipers, tube clips, shields and clamps for miniature vacuum tubes, instrument and relay springs. There are many other electrical applications where semi-elevated temperatures are encountered in which silver-magnesium-nickel offers attractive possibilities.



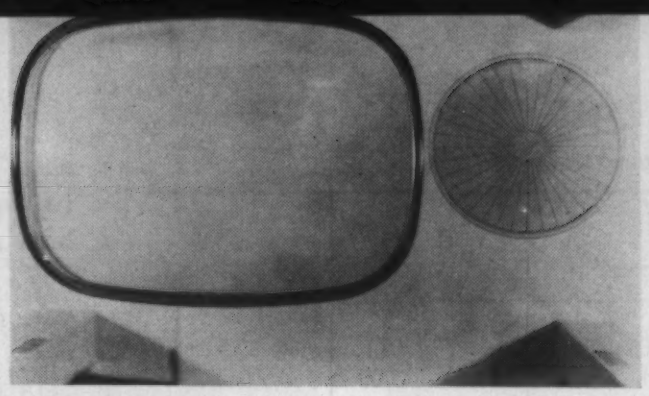
Effect of magnesium content *on mechanical properties of strip.*



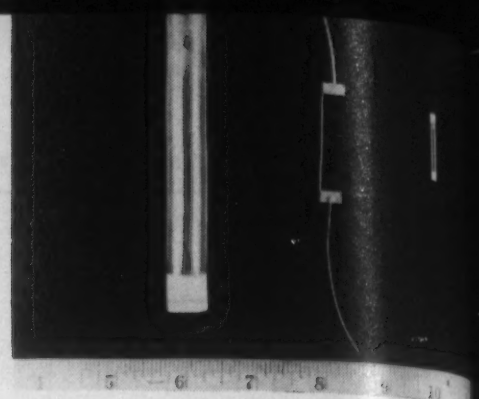
***Oxidation hardening curves** for 99.5 silver-0.27 magnesium-0.23% nickel strip.*



Airplane window *and instrument cover are coated with transparent conductive film to prevent icing and fogging.*



Kinescope face plate *and instrument dial are coated with tin oxide conductive film to dissipate static charges.*



Precision resistors *with external conductive coating exhibit little change in resistance during wide temperature variations.*

A New Look at

Transparent Conductive Coatings

They can be used to:

- *Generate heat to prevent icing and fogging of glass.*
- *Prevent the buildup of electrostatic charges.*
- *Create broad electric fields to energize panel type lighting fixtures and wireless neon lights.*

by S. M. Dodds, *Research Laboratory, Pittsburgh Plate Glass Co.*

■ Due to a unique combination of properties, transparent electrically conductive coatings occupy a special niche in product design. Employed principally as resistance and grounding elements on glass surfaces, these coatings are also widely used to create broad electric fields in special lighting fixtures and in precision resistors that are insensitive to temperature changes. Because of their transparency, these coatings have been mainly applied to glass surfaces. However, films have also been successfully applied to ceramic materials, quartz, vitreous enamels and some metals. The high temperature necessary for film formation precludes the coating of plastics and similar materials.

The coatings

The principal type of transparent film currently used consists of a semiconducting metal oxide layer, whose conductivity depends on the number and the characteristics of the impurity centers in its crystal structure. All of the coatings offered by the Pittsburgh Plate Glass Co. under the NESA trademark consist of a tin or stannic oxide film.

These coatings vary in light transmittance from 70 to 88% and in surface resistivity from 25 ohms to 10 megohms. Surface resistivity is defined as the electrical resistance of a square area with bus bars along two opposite edges and is independent of the size of the square and the thickness of the film. Coating thicknesses range from 50 to 550 millimicrons (2 to 20 x 10^{-6} in.).

The coatings are usually applied by spraying hot glass (at 900 to 1300 F) with a solution of stannic chloride containing various additives. Films can also be be applied by dipping the substrate in the solution or by direct application of stannic chloride in the vapor phase. As indicated by x-ray diffraction, the coating is predominately made up of stannic oxide, a compound that is ordinarily nonconductive and opaque.

The coatings are strongly bonded to the substrates and are usually harder than the substrates themselves. They are chemically inert to common acids and caustics such as hydrochloric, nitric and sulfuric acids, acqua regia and potassium and sodium hydroxide. They are also insoluble in many solvents such as water, alcohol and acetone.

Because of their hardness and resistance to attack, coated parts may be handled and cleaned without damage if reasonable precautions are taken. Scratches should be avoided since they cause film discontinuities and may affect current flow.

Although the films are unusually inert to acids and solvents, they may be selectively or completely reduced to metallic tin by hydrogen. This pure tin coating is easily removed from the base surface. Hydrogen for the reducing operation is usually produced by the reaction of certain acids with various metals (particularly hydrochloric acid and zinc).

Properties

Resistivity — Although usually classified as a semiconductor in structure, a tin oxide conductive coating possesses specific resistivity and conductance properties that are closer to metals than they are to semiconductors. These

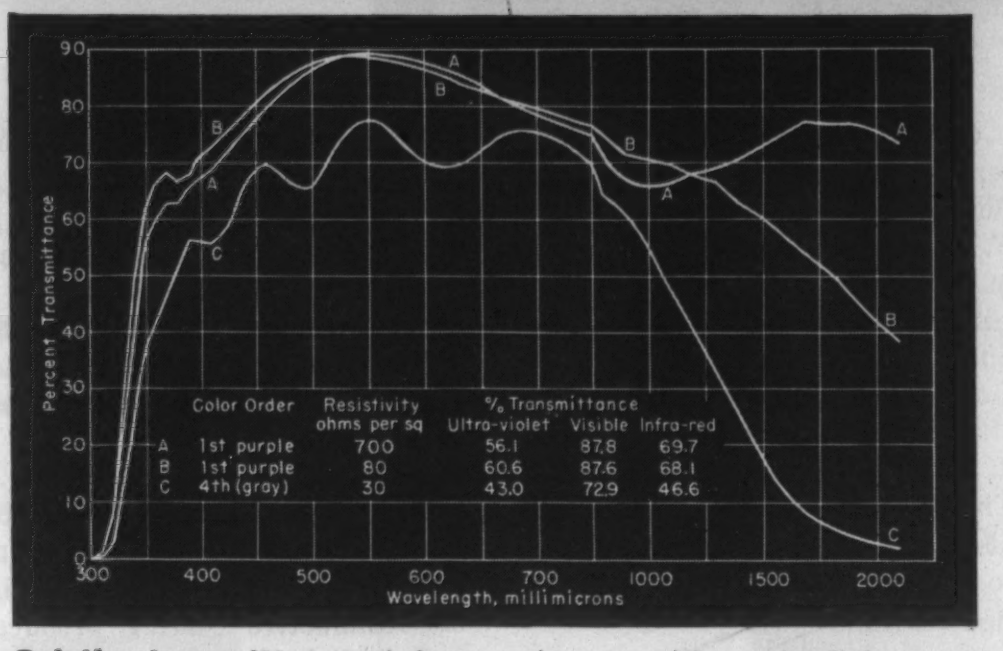
tings might well be termed nsition materials. Films have n made with a specific resis- ity of 2.5 x 10^{-4} ohm-cm. A mparable value for bismuth— e least conductive of the metals th the exception of tellurium— 1.19 x 10^{-4} ohm-cm at 64 F.

It is interesting to note that oatings exhibit different resis- ivities with different current ori- ntations. Transverse measure- ments taken normal to the sub- trate result in resistivity values 20 to 60 times higher than those ade by longitudinal measure- ents parallel with the substrate.

There is further evidence to dicate that the coatings bridge e gap between semiconductors nd metals. Semiconductors have egative temperature coefficients f resistivity and metals have ositive coefficients. The tempera- ure coefficient of tin oxide films an be made either positive or egative at will, and can be made uite small. Coefficients of com- ercial films vary between —0.000055 and —0.00025 per deg F. Temperature coefficients as low s 0.000018 per deg F have been easured, and it appears that ero coefficients can be produced y more meticulous control dur- ng processing.

The resistivity of conductive lms, particularly thin, colorless lms, may not be completely sta- le under all conditions. Since the oatings are somewhat hygro- scopic, their resistance may de- crease with increased humidity. They are also photosensitive to some extent and increasing illumi- nation produces a decrease in re- sistance. Films placed in a vac- uum decrease sharply in resist- ance, but tend to recover when returned to normal pressures. Films also exhibit a slight ten- dency to increase in resistance during aging. This phenomenon is not universal, however, and reasons for its behavior are not completely understood.

Power density—Tests indicate that when used in a d.c. circuit or in an a.c. circuit up to 400 cps, conductive coatings obey Ohm's law. Information on coating be-



Relative transmittance *of three coatings exposed to solar light.*

havior at higher frequencies is not available.

Coatings are capable of withstanding high power densities without failure. Densities of 5 w per sq in. are common in commercial use and densities of 6 w per sq in. have been tested continuously for hundreds of hours at temperatures over 500 F.

Color and light transmittance—Useful conductive coatings can be applied up to about 50 millimicrons in thickness before any color appears in the film. Higher thicknesses exhibit the characteristic color interference of thin films in reflected light.

The index of refraction of tin oxide coatings is 2.0. This compares with an index value of 1.53 for glass. Because of this higher index, coated glass reflects more light and transmits less light than uncoated glass. Light transmittance curves of glass plates coated to various thicknesses exhibit wave-like shapes with a series of maxima (purple in reflected light) and minima (green in reflected light). After the third color order is exceeded, the various colors tend to lose their identity and the coatings appear grayish in reflected light.

In general, thick coatings are less transmissive than thin coatings. There are exceptions, however, and the relative transmittance of thick and thin coatings is determined to a great extent by their position relative to the several maxima and minima.

Light transmittance values for three samples of conductive films on 0.121 in. thick lime-soda glass (commercial plate glass) are shown in the accompanying figure. Source for these measurements was solar light. Note the large difference in resistivity between coatings A and B despite the fact that they both possess the same thickness. Visible transmittance is about 88%—close to the maximum that can be expected for tin oxide films.

Transmittance in the infrared region is about the same for both films up to about 1200 millimicrons. At this point the transmittance of the lower resistivity sample (B) exhibits a sharp drop. This is in line with the theory that good electrical conductors are also good heat reflectors. Note also the low transmittance in the infrared region of sample C, which has a square resistivity of only 30 ohms.

Heat reflectance and emissivity—Thin, high resistivity conductive coatings on glass have only a slight effect on emissivity. As thicker films are applied, however, emissivity drops and reflectance goes up.

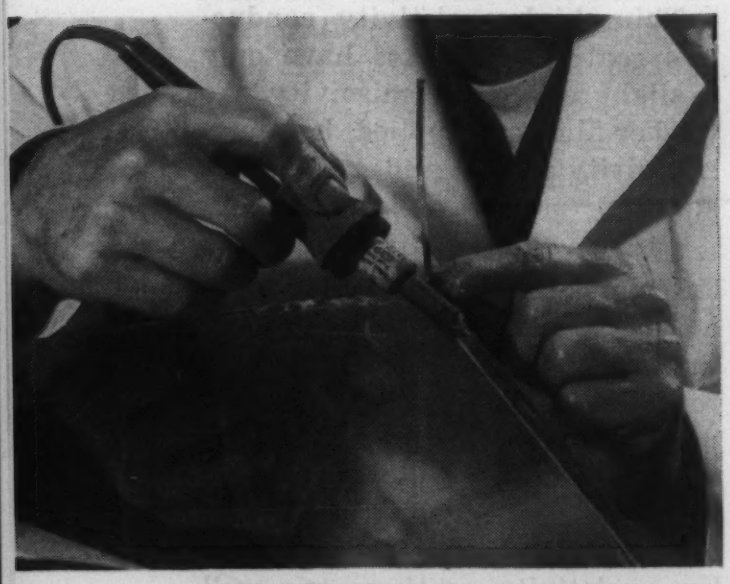
Of two films with the same thickness, the film with the lowest resistivity will also possess the lowest emissivity and highest reflectance. Coatings of a thickness indicated by fourth order colors with a resistivity of 20 ohms have an emissivity value of only 0.52. For this reason thicker, low resistivity coatings are well suited for use in transparent heat shields.

Coefficient of expansion—The temperature coefficient of tin oxide coatings is 3.3 x 10^{-6} per deg F. Since the expansion coefficient of lime-soda glass is 4.4 x 10^{-6} per deg F, it is indicated that conductive films are under compression. Compressive strains can be eliminated by using a glass with a lower coefficient of expansion. The lower coefficient glasses will also be found to be more resistant to thermal shock.

Applications

Generation of heat—One of the principal applications of conductive coatings is for the prevention and removal of ice from glass surfaces and for the prevention of water vapor condensation. Most installations of the coating for deicing and defogging have been as windows of airplane cockpits. However, successful installations have also been made in ships, railway coaches, automobiles, street cars, locomotives, tank periscopes and various instruments.

When used on airplane cockpit windows, the coating is capable of generating large amounts of heat without producing high local temperatures. In contrast, conventional heated glasses utilize small diameter resistance wires that are embedded in the laminated glass assembly. When power is applied, the localized expansion of the plastic interlayer around the wires is sufficient to cause optical distortion.



***Braided terminals** are soldered to bus bars that run along opposite edges of coated glass surface.*

Another advantage of the conductive coating is that heat is generated at the place where it is used and there is no loss conducting the heat to the windows. A typical window assembly usually consists of four layers: a relatively thin outer pane of tempered glass, the conductive coating, a bonded plastic interlayer and a second inner tempered glass plate. Unless the assembly is made extra thick for additional strength, the one conductive coating produces sufficient heat for both deicing and defogging.

Depending on operating conditions, the power necessary to operate these panels ranges from 1500 to 3200 Btu per sq ft per hr. To prevent overheating, controls are necessary and temperature sensing elements of the wire grid or Thermistor type are usually placed in the laminated assembly close to the conductive coating.

Since they are capable of dissipating large amounts of heat without attaining high temperatures, coated glass panels are particularly well suited for use in portable and fixed space heaters. These heaters are assembled with the uncoated glass surface facing the user, partly as a protection from electric shock and partly because the emissivity of the glass surface is almost double that of the coated surface. An additional directional effect can be obtained by mounting a heat reflector facing the coated surface.

Prevention of static charges—Conductive coatings have been used for a number of years to prevent the accumulation of static charges on dielectric surfaces and on the face plates of sensitive electrical instruments. These coatings are usually applied in a thickness that does not show color in reflected light. Resistivity values up to 100,000 ohms have proved effective for this application.

Antistatic coatings have also been applied experimentally to the outside of airplane windows. These coatings must be thin and resistivity ranges from about 1 to 10 megohms. In this range the coatings are only mildly effective in reducing electrical noise. Also, the lower resistivity coatings have the disadvantage of interfering with radio signals.

Coatings have also been applied to the inside surfaces of the face plates of cathode ray tubes. Bombardment of the face plates with electrons builds up a negative charge that tends to repel other electrons. The coatings, by providing a means of draining off this charge, help to increase tube efficiency.

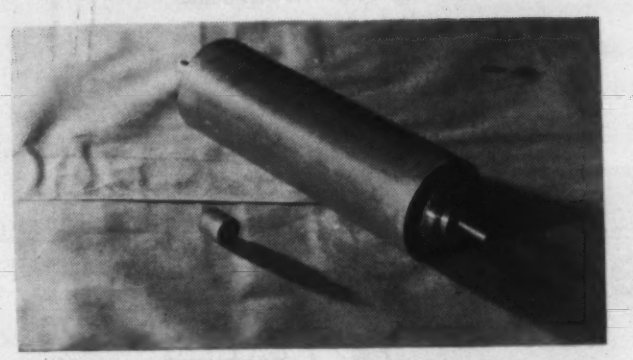
Creation of electric fields—Because of its unique combination of transparency and conductivity, conductive coatings are often used to create special lighting effects. In a typical application, phosphors incorporated in a dielectric are applied over a conductive coating on glass. A metallized electrode is applied over the phosphor layer. Excitation of the phosphors in an alternating field produces light that is emitted through the glass. Principal applications include clock faces and light switch covers.

A broad high frequency field can also be used to activate neon signs without any direct electric connection to the various letters. Electrodes for the signs consist of a single glass plate with a divided coating. Letters placed close to (but not necessarily touching) the electrodes light up when the electrodes are energized. The wireless feature of these signs permits letters to be changed at will.

Precision resistors—As mentioned previously, the temperature coefficient of resistivity of tin oxide conductive coatings is quite small and can be made positive or negative during the coating process. Consequently, coatings can be made that exhibit little change in resistance as the temperature changes. This property and the chemical stability of the coating make it ideally suited for use in precision resistors. These components show little change in resistance over a wide temperature range and are available in tubular, flat and solid rod shapes.

Tubelike molds *are held to 0.002 in. tolerance on curvature over their entire length and 0.001 in. on concentricity. Core of roller is held concentric by precision spiders.*

MATERIALS AT WORK



Rolls can be produced *in diameters from 1 1/16 to 7 in. in lengths up to 108 in.*

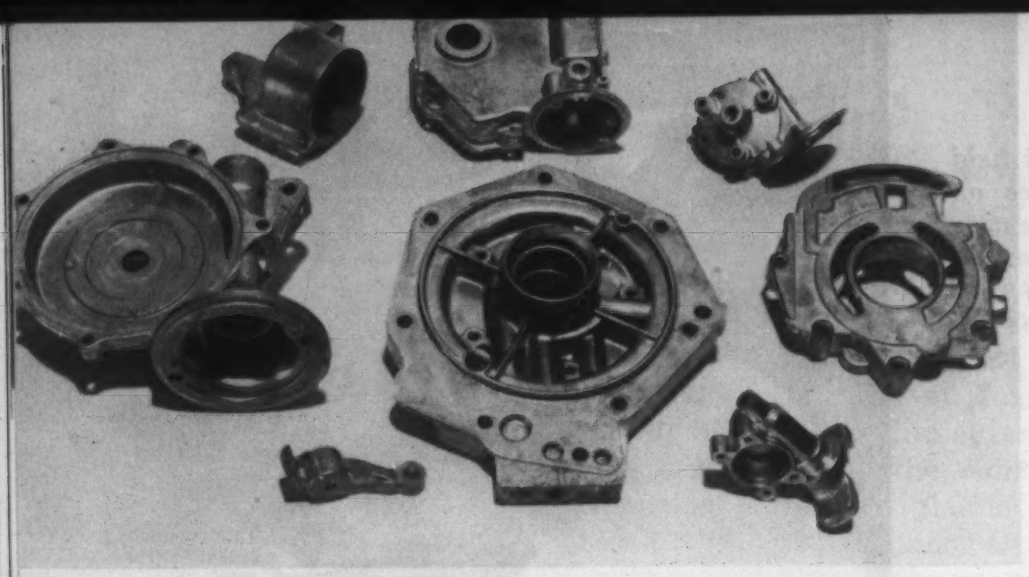
New silicone rubber extruded for letterpress rolls

A new type of silicone rubber containing vinyl groups is being used to produce large as well as small diameter letterpress rolls. The rolls, molded by a special hydraulic process, have extremely accurate diameters, a glasslike finish and a good bond to the core.

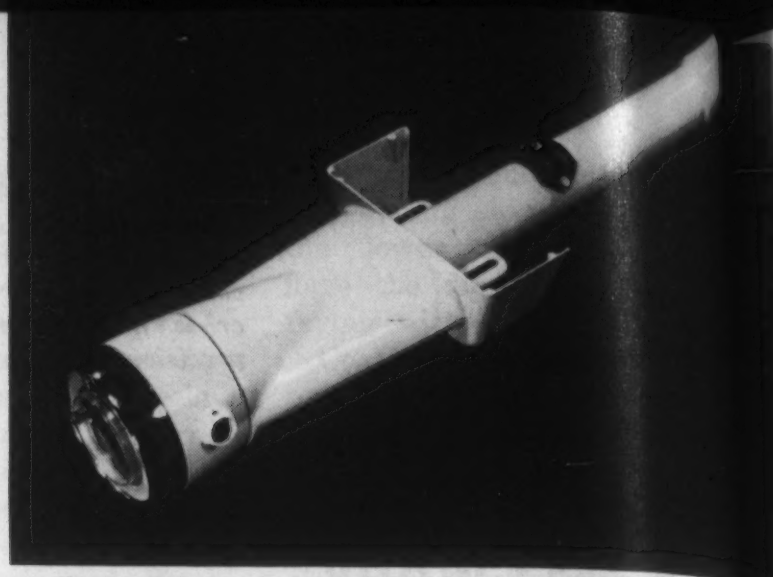
In making rolls the usual process is to wrap rubber over a steel core and then grind it to a special diameter. At the Roller Corp. of America, the new silicone rubber, developed by Union Carbide & Carbon Corp. (See M&M, July '56, p 180), is first milled into a doughy state, too soft for sheeting and wrapping. After placing the rubber in a cylindrical container it is put into a 300,000-lb hydraulic extrusion press. The rubber is then forced through a series of diffusion heads that further mix the material and disperse any air in the stock into minute particles. From these heads the rubber flows into a mold of hardened die steel with 5 to 8 microin. finish.

The capped mold is placed in an oven for curing at 2 hr at 380 F. During this process, extreme vulcanization pressures are built up so that the end product is a roller with a dense structure with no ply separations. A calculated shrinkage of 1/32 in. permits roll to slide out of mold.

Rubber is shown *extruding from filled mold. Mold is then locked by heavy steel caps firmly closing both ends and is placed in an oven for curing for 2 hr at 380 F.*



***Aluminum and zinc** die castings are used by Chrysler for functional parts of transmissions and accessories.*



***Magnesium** die castings were chosen by Oldsmobile for this steering column shroud.*

Die Castings

serve autos from engine to trim

for:

- *Load-carrying parts*
- *Intricate shapes*
- *Attractive finishes*

■ Zinc and aluminum die castings are now used in every section of the American passenger automobile. The increased number of interior accessories and the use of heavier exterior trim have played a significant part in the record job shop die casting sales reported for 1955. However, a survey completed by the American Die Casting Institute also reveals a steady gain in the number of functional parts using zinc, aluminum, and magnesium die castings.

As a result of this demand, job shops shipped 117 million pounds of aluminum die castings for automotive parts and 327 million pounds of zinc. Previous high for aluminum was 57 million in 1954, and for zinc, was 173 million in 1950.

Transmission and engine parts

Savings in machining operations as well as weight have resulted in the use of die castings for load-carrying parts. Outstanding among these are aluminum die cast torque converters used in automatic transmissions. In some cases this represents a redesign from cast iron with consequent reduction in machining and finishing operations. Most stators are also aluminum die castings.

A prime example is the 1956 Chrysler line. The torque converter housings, weighing about 10 lb, are among the largest die castings produced anywhere on a full production basis. The transmission extension, with 5-lb weight and 12-in. length, and the impeller cover, weighing from 9½ to 11 lb, are also aluminum die castings. This complex unit is held to production tolerances of 0.002 in.

Integral parts of transmissions are now being die cast, including the valve body assemblies of automatic transmissions. The dies for the Studebaker valve body assembly have as many as 48 inserts in each section of the two-cavity die.

Many engine parts have also been designed as die castings. In the Chrysler line, valve bodies (units with integral oil channels and valve ports) are aluminum die castings ranging in weight from 0.2 to 1.4 lb. Other engine units include governor bodies and carburetor parts.

Steering assemblies, both standard and power, use many die cast components. General Motors engineers specified five different die cast parts because of the savings in weight, the simplicity of design and the economies inherent in mass production.

Interiors and accessories

The ability of die casting to hold close tolerances, permit intricate shapes and cut material cost and weight are factors that account for the trend to complex die cast instrument panels and interior components.

The 1956 Chrysler New Yorkers and Windsors use a 22-lb zinc die cast panel formed in three sections. It is cast with cutouts for all dials, radio components, buttons, switches, glove compartment, clock, and radio speaker grille. Other parts include push-button transmission control housings, bezels and glove compartment doors. Smaller units, such as the interior light housing, heater control and windshield wiper knobs are also die cast.

Using a die cast instrument panel as the base for mounting individual units fulfills both functional and decorative requirements. Oldsmobile and Cadillac panels are so designed, with the Cadillac unit being one of the-

gest die cast panels in any odern car (11 lb).

Pontiac uses die cast aluminum r the direction signal control using. Zinc die castings are ed for air conditioning air-out- bezels, control panels, defros- air outlets, ignition locks and linders, heater control housing dies, and the mechanism and al of speedometer assemblies.

xterior trim and units

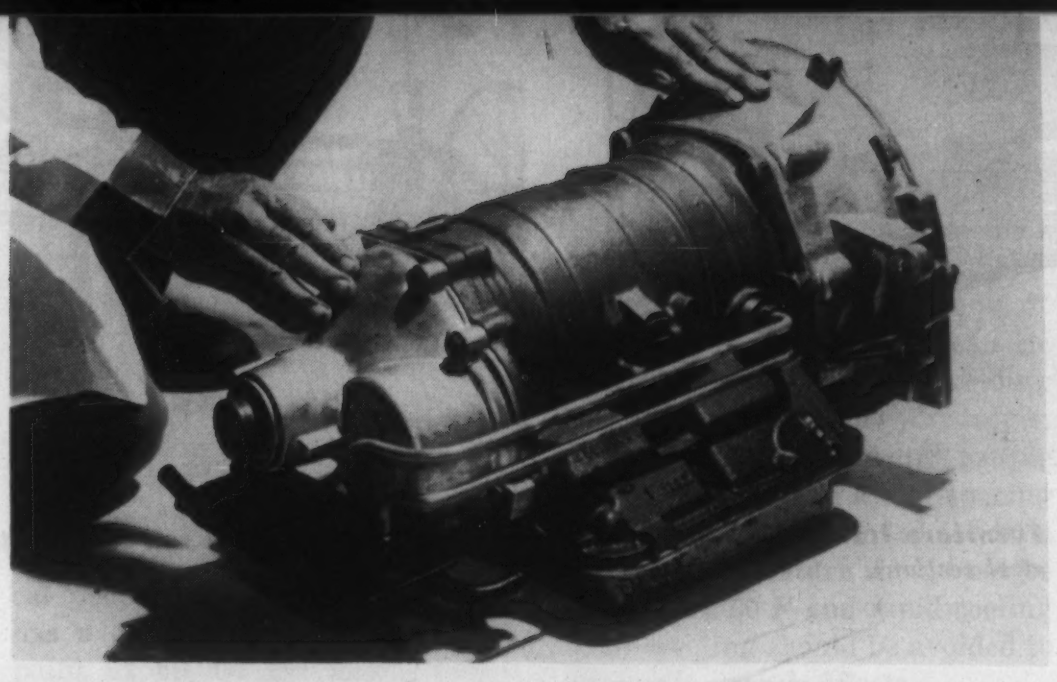
The corrosion resistant quali- ies of die cast components and he possibility of plating with at- tractive wear resistant finishes have led to an extension of their use for exterior parts. In addi- ion, the trend to larger and heav- er units has upped the consump- ion of die castings. Among the parts involved are: grilles, door handles, window trim, bezels, ornaments, head and tail light assemblies, lock units, moldings, name plates, emblems and frames.

The dual purpose quality of die castings (function and beauty) is seen in the Pontiac's use of zinc for rear compartment door han- dles formed in the shape of the Star Chief emblem. The 27 series has a rear compartment door han- dle bezel that is an ornamental circular bezel used in conjunction with the gull-winged ornament as a deck lid handle.

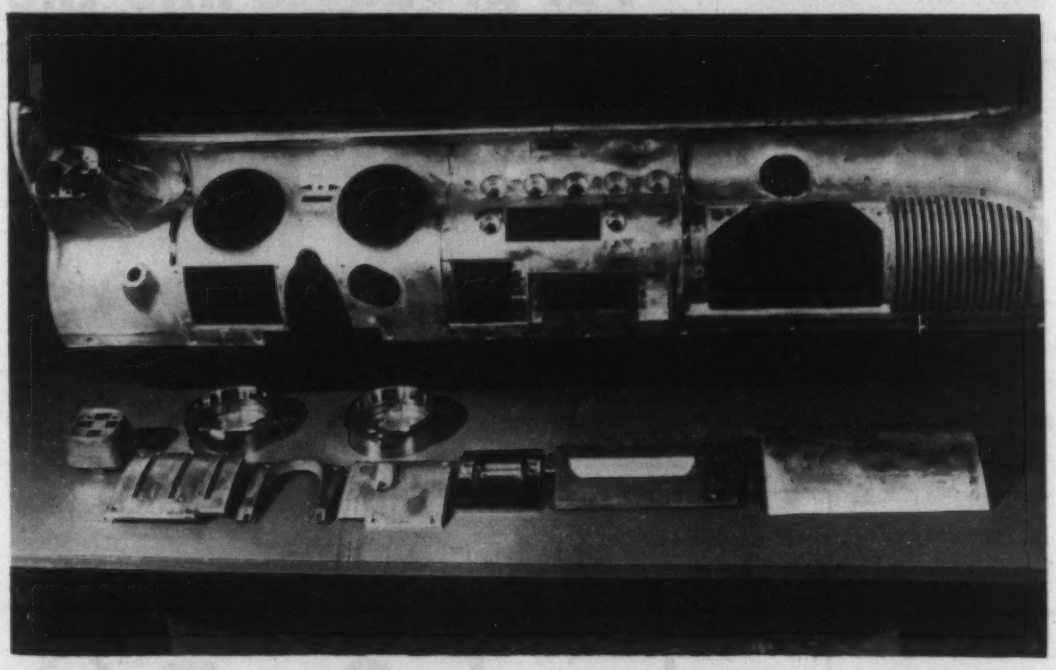
Chevrolet employed over 33 lb of zinc die castings in the 1956 car, with the major portion speci- fied for exterior parts. Dodge had only six applications for die cast zinc exterior parts in 1955, but fifteen in 1956.

Stamped assemblies are being replaced in increasing numbers. Lincoln, for example, used a stamped unit for its front fender extension headlamp in 1955, but switched to a die casting in 1956 for this unit as well as tail and parking light assemblies. Other Ford divisions followed suit and estimated zinc averages for the Ford line are: Ford, 25 lb; Mer- cury, 36 lb; Lincoln, 40 lb.

There is every indication that this upward trend in the use of die castings will continue, partic- ularly in functional applications. Weight reduction has been an in- creasingly important factor in recent years and the use of light metals has helped offset the weight increases due to power accessories and automatic features. Now, with the addition of air condition- ing equipment, weight is more critical than ever.



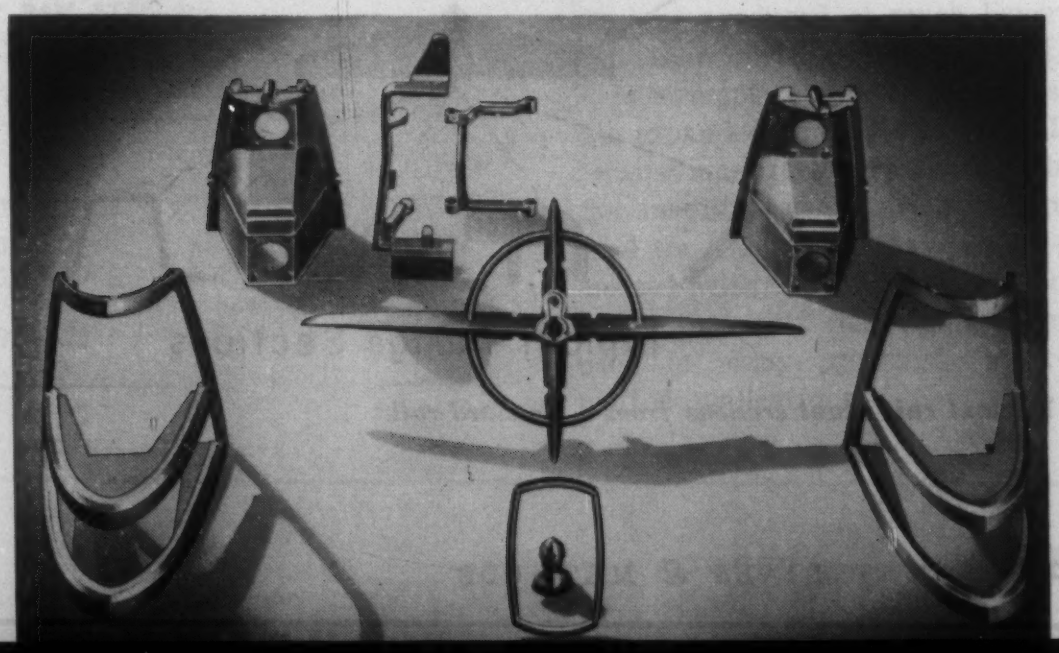
Transmission parts *such as the flywheel housing and rear bearing retainer of this Pontiac unit are being redesigned as aluminum die castings.*

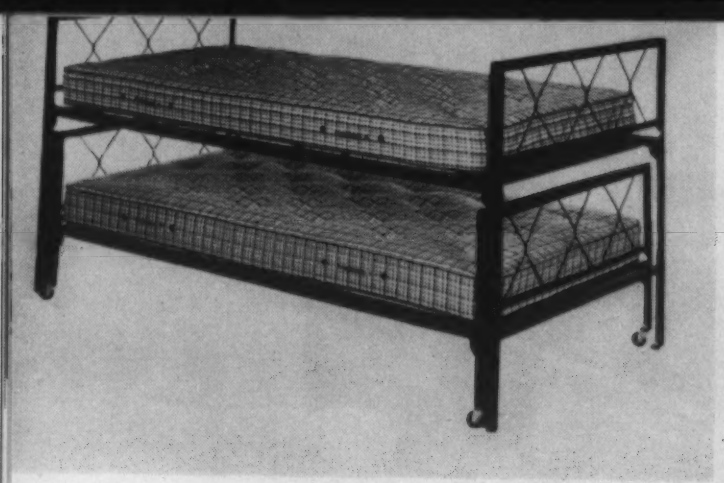


Instrument panel *of Chrysler is three-section zinc die casting weighing 22 lb. Components to be mounted on panel are also die castings.*

Another look into the future is provided by the fact that Doehler-Jarvis is now producing six-cylin- der engine blocks of 50-lb weight on an experimental basis (see M&M, Feb '56, p 99). A die cast V-8 aluminum block is also under development.

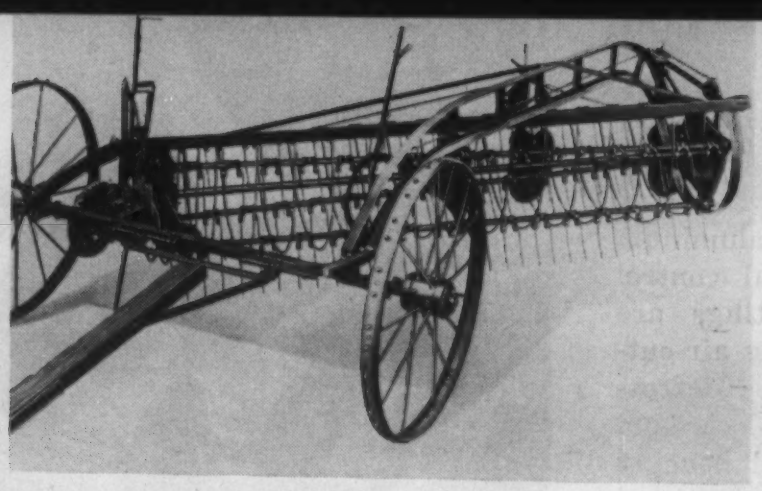
Exterior units, *such as the tail and back-up lights of the Continental Mark II, are zinc die castings tending to become larger and heavier.*





Inland Steel Co.

Furniture frames *make use of rail steel sections.*



Hay tedders *use many rail steel parts.*

Inland Steel C

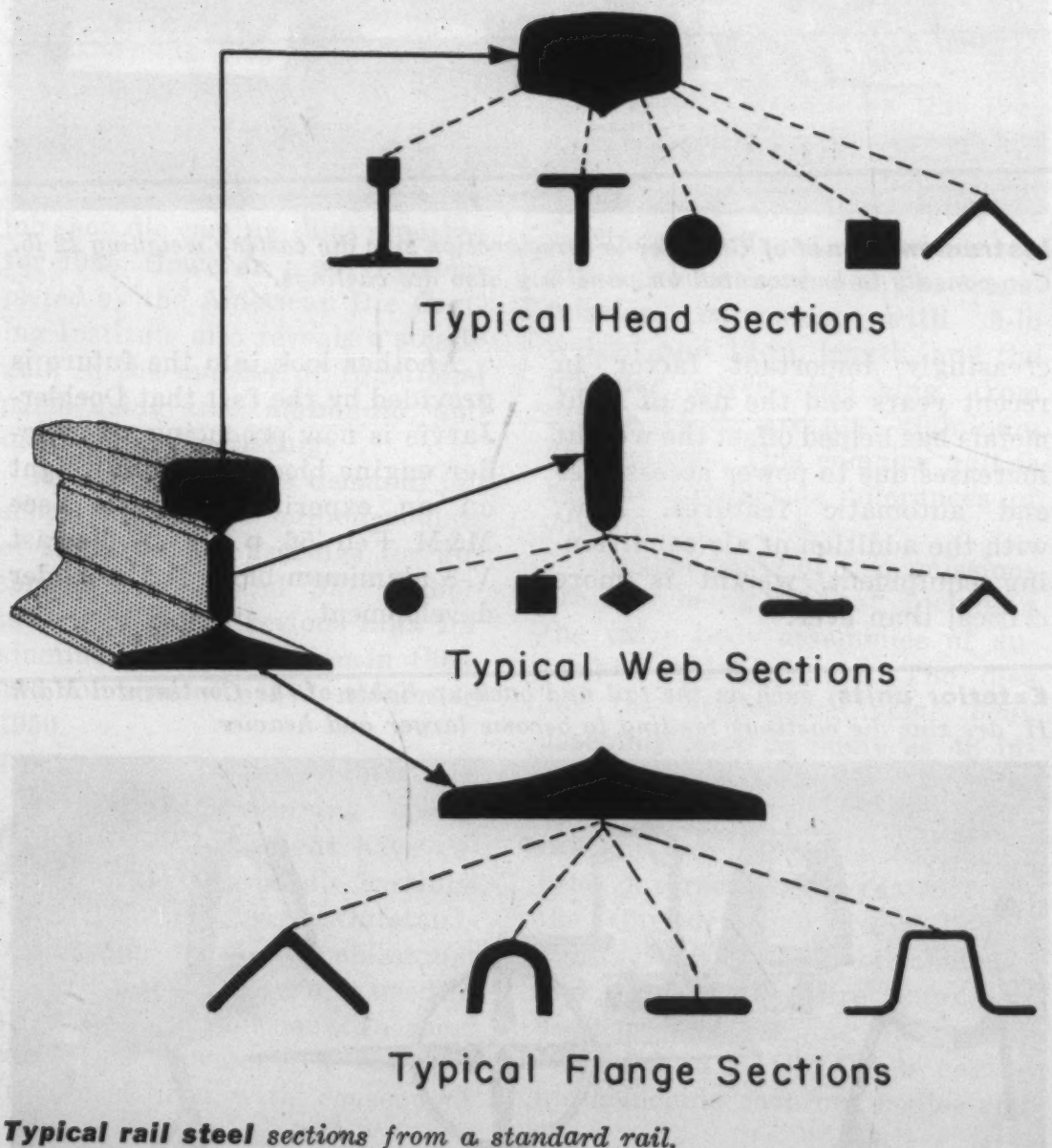
Jack handle *rolled fr rail steel.*

For products like these ↑ try

New Shapes from Old Rails

. . . they can provide lighter, less expensive products.

by W. H. Jacobs,
Rail Steel Bar Assn.



***Typical rail steel** sections from a standard rail.*

■ Steel used in the production of railroad rails is manufactured to more rigid specifications and tested and inspected more exhaustively than any other heavy product of industry. Consequently, when rails are removed from service, much of the steel becomes raw material for the production of other products, rather than being scrapped. Such products are used in agricultural machinery, industrial equipment, household furniture and construction.

Trade name for steel sections hot rolled from standard railroad Tee rails is Rail Steel. These rails are produced under rigid specifications from deoxidized carbon steel and only those rails that have served satisfactorily are used in producing rail steel products. Major reason for removal of a rail is partial wearing down of

Rail steel is used for the frame of this grain loader.

the head resulting from wheel friction.

Rails taken out of service by the railroads are classified as rails for rolling, relayers and scrap. The term *rails for rolling* is applied to the grade of rail that can be utilized by rolling mills for rolling into other products. A rail for rolling must be free from bends or kinks, vertical camber, lateral camber exceeding 2 in. per 10 ft length, head wear exceeding 25% of the original head section, and side flow that exceeds ¼ in., is slivered, or will lap in rolling.

Evolution of rail steel sections is shown graphically. In all cases, except where large rails are rerolled into smaller mine rails, the rail is slit into head, web and flange billets each of which is rolled into a definite section.

Rail steel can be produced in almost any rollable shape that has a weight less than 5.5 lb per ft. This limitation is set by the size of the rail steel billet. For a given strength, the section is lighter in weight than that of any other commercial carbon steel. Some of the many shapes that can be produced are indicated in the graph.

Properties

The chemical composition is unchanged during service on the railroad, but unlike the rails, rail steel products are not sold to chemical specifications. Mechanical properties govern. Rail steel has a guaranteed minimum yield point of 50,000 psi and a minimum tensile strength of 80,000 psi. Average actual yield point is above 65,000 psi and actual tensile strength ranges from 100,000 to 130,000 psi.

On annealing in the range 1250 to 1300 F, strength falls about 10% below the as-rolled strength and Brinell hardness ranges from 190 to 228.

No general elongation requirements are specified. For reinforcing bars, it is usually required that the elongation in 8 in. be equal to or greater than 1,000,000 divided by the tensile strength in psi. Average values for rail steel containing from 0.52 to 0.80% carbon are 16 to 20% elongation and 29 to 38% reduction of area.

As can be noted in the table of chemical requirements for rails, the carbon content ranges from about 0.5 to 0.8%. Rail steels are, therefore, high carbon steels and are subject to the same limitations in working as other high carbon steels. They are considerably harder than the low carbon steels and can be cold formed only to a limited extent but can be hot formed readily. Machinability is similar to that of other high carbon steels and the index (based on B1112 steel as 100%) is about 45 to 55%.

Rail steel or combinations of rail steel and mild steel can be joined by standard arc welding procedures using low hydrogen electrodes. A minimum groove angle of 60 deg and a root spacing of ⅛ in. is recommended for butt welds. Temperature should not be lower than 50 F and rapid cooling after welding should be avoided to eliminate quench effects.

Applications

Best known application of rail steel is in concrete reinforcing bars where it has served for about 40 years in the construction of many buildings, bridges, superhighways and other large structures. Steel fence posts and highway markers also consume large quantities.

However, there are many other applications. In the automotive industry, rail steel is used for the production of bumper supports and jacks and jack handles. Seeding, cultivating and harvesting implements in the agricultural industry use many parts produced from this material. In the equipment fields, shelving, storage racks, lockers, conveyors, tools, hoists and grinding balls are typical parts produced from rail steel. Among other products are steel lawn furniture and bed spring frames.

New uses are being developed regularly. A manufacturer of farm tools designed a new plow blade that the designers decided had to be produced from billet steel. However, a new roll section was developed and the part was rolled from rail steel. The product was produced at much lower cost than had been anticipated. This attempt to develop new uses has expanded since World War II because manufacturers, faced with the inability to obtain sufficient steel for their needs, have experimented with rail steel and have found that this material can be used in many previously unexploited applications.

COMPOSITION OF RAIL STEELS[1]

	Nom. Weight, lb/yd			
	61-80	81-90	91-120	121 and over
Carbon, %	0.55-0.68	0.64-0.77	0.67-0.80	0.69-0.82
Manganese, %	0.60-0.90	0.60-0.90	0.70-1.00	0.70-1.00
Phosphorus, % (max)	0.04	0.04	0.04	0.04
Silicon, %	0.10-0.23	0.10-0.23	0.10-0.23	0.10-0.23

[1] ASTM Spec A1-54T

Versatile Reinforced Plastics Solve Design Problem

The many forms and grades of reinforced plastics allow the designer to choose from a wide range of properties and characteristics in solving tough design problems.

by G. A. Ebelhare, *Synthane Corp.*

The Problem

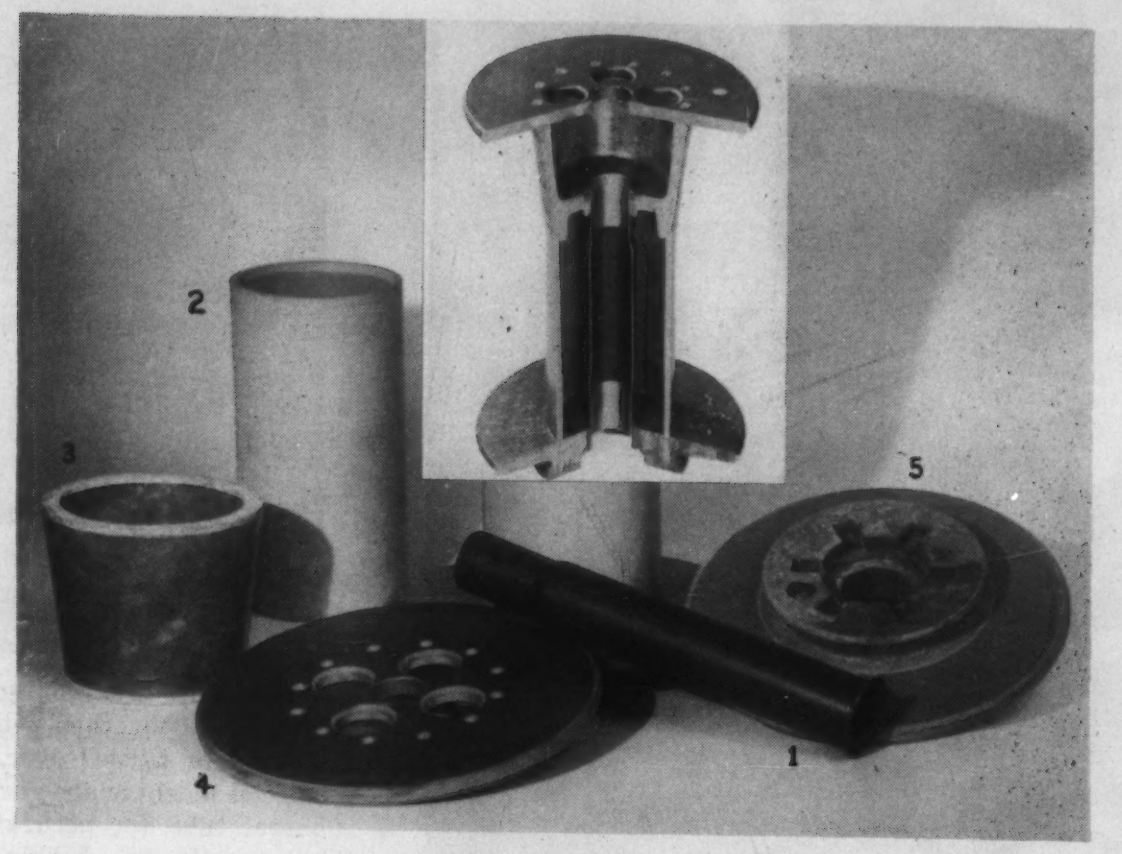
A rewind bobbin had to be designed to allow quantity production of rayon yarn with a minimum of down-time. In producing rayon, the raw filament is first wound on bobbins from which it is later rewound to produce desired twist. To minimize vibration at the high speeds at which bobbins rotate, they must be as light as possible, almost perfectly concentric and accurately dynamically balanced.

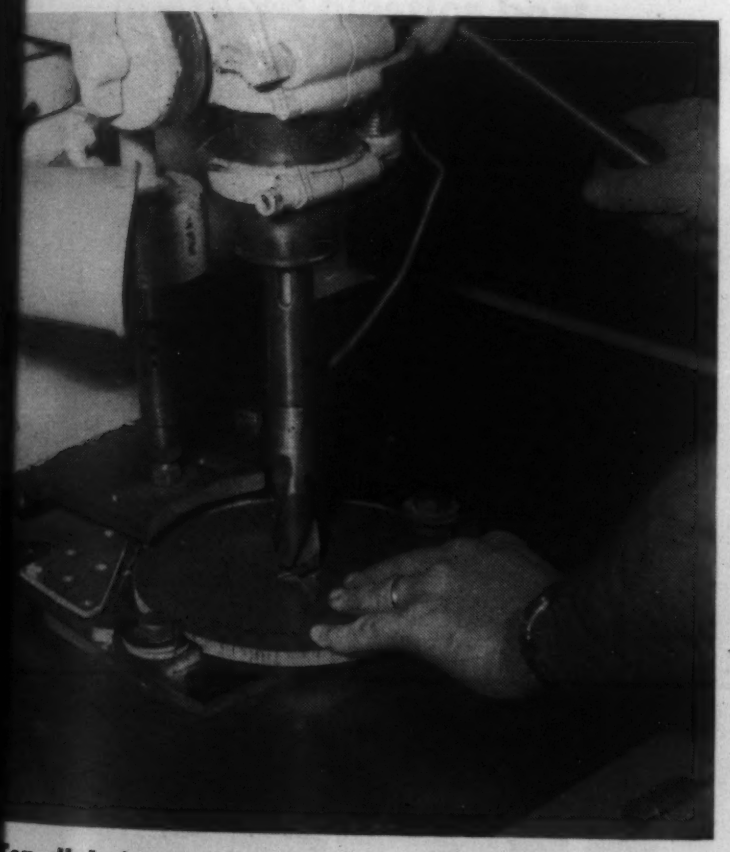
Since considerable shrinkage of the rayon may occur with changing moisture conditions, the bobbin's barrel must resist high crushing forces, and the bobbin itself must not be affected by moisture. And finally, the whole structure must be durable enough to withstand rough handling during installation or removal, or during normal shop handling.

Bobbins are large, *to minimize handling. They stand 10 in. high with end disks 7 in. in diameter and are capable of holding 9 lb of yarn.*

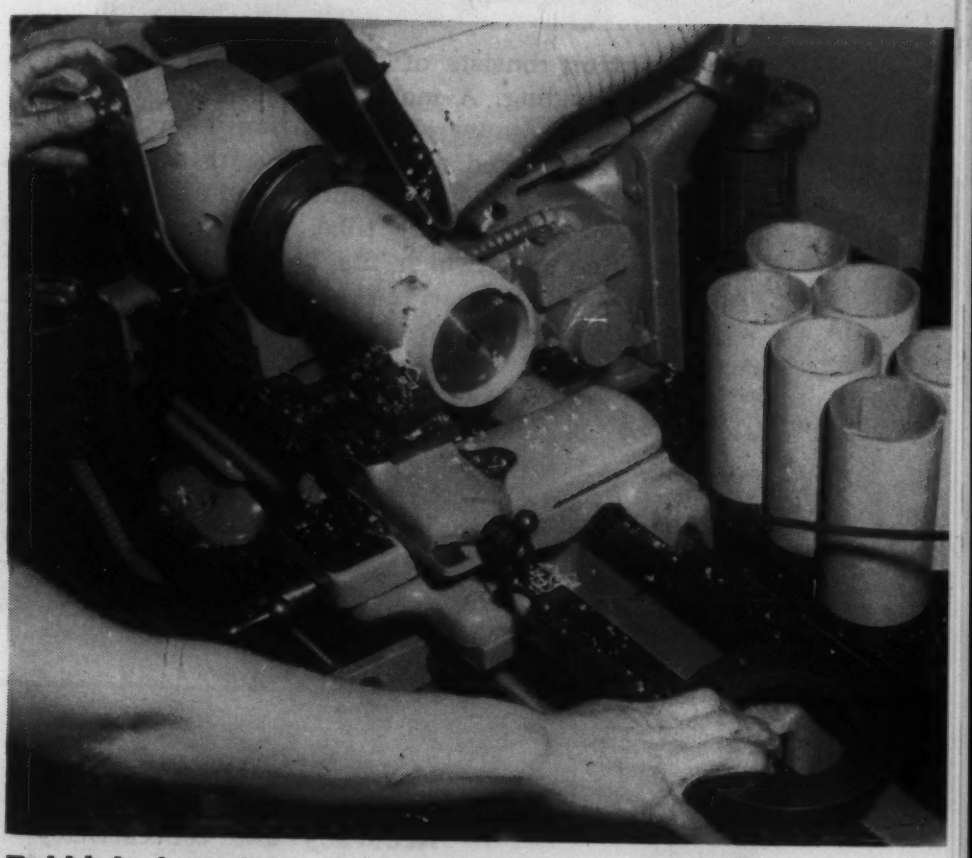
The Solution

Five different materials are used in this unique bobbin design to meet end service and fabrication requirements. Bobbin consists of 1) steel center tube; 2) barrel made of grade XX paper-base phenolic laminated tubing; 3) center cone section consisting of a cloth-base phenolic macerated molding; 4) top end disk made of grade L-RF cotton mat-based phenolic laminate sheet; and 5) bottom end disk consisting of a paper-base phenolic macerated molding.

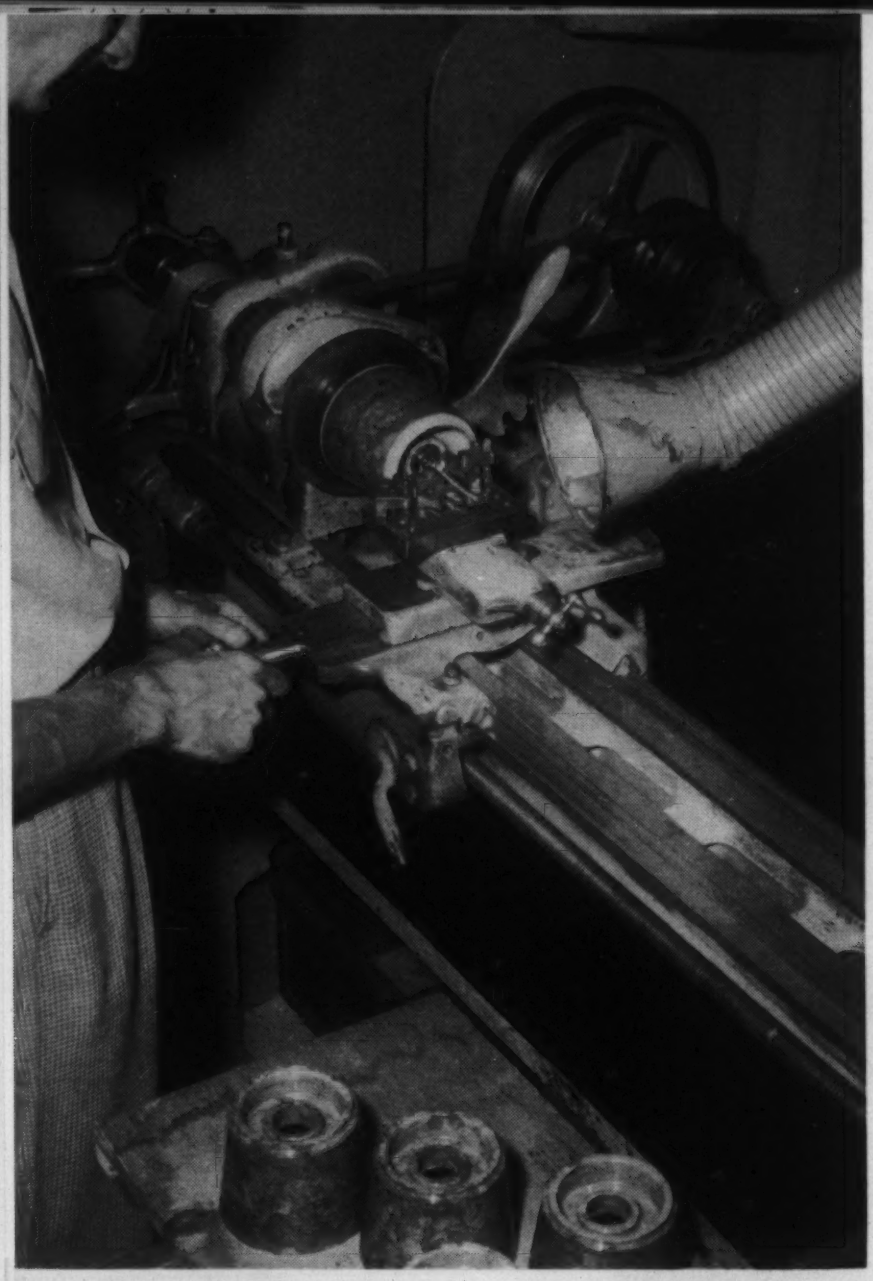




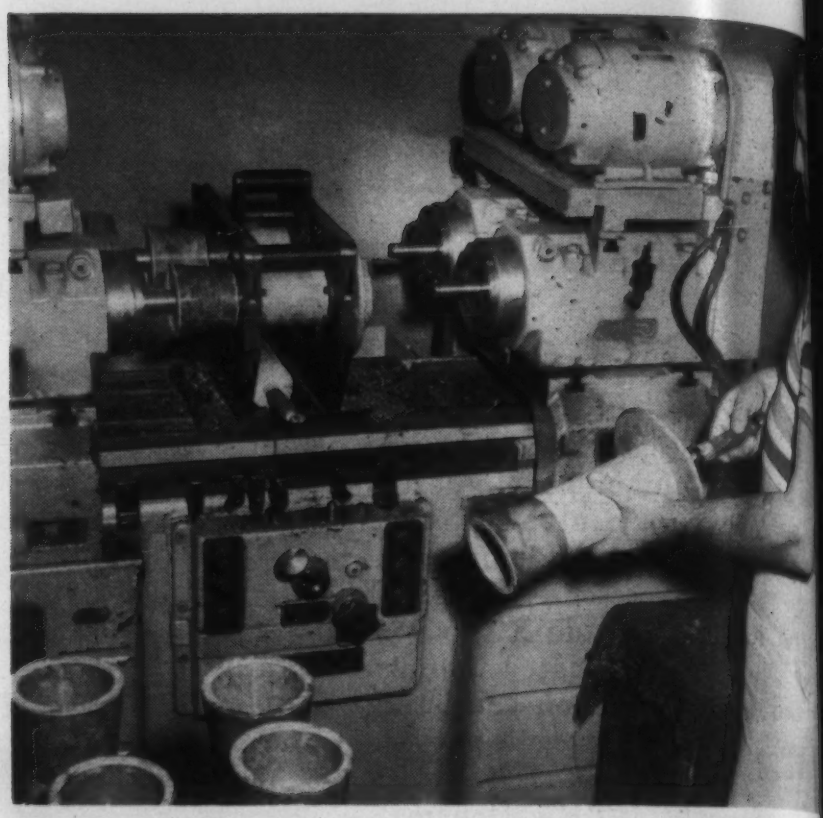
Top disk is machined to a high degree of accuracy from L-RF grade cotton mat reinforced high pressure phenolic laminate. Material was selected because of its high impact qualities, good machinability, good dimensional stability, and its ability to maintain a smooth surface over which the rayon yarn travels when spools are loaded and unloaded. It also has low moisture absorption, essential for textile bobbins which are subjected to relatively high humidity conditions. Holes must be accurately located to aid dynamic balancing.



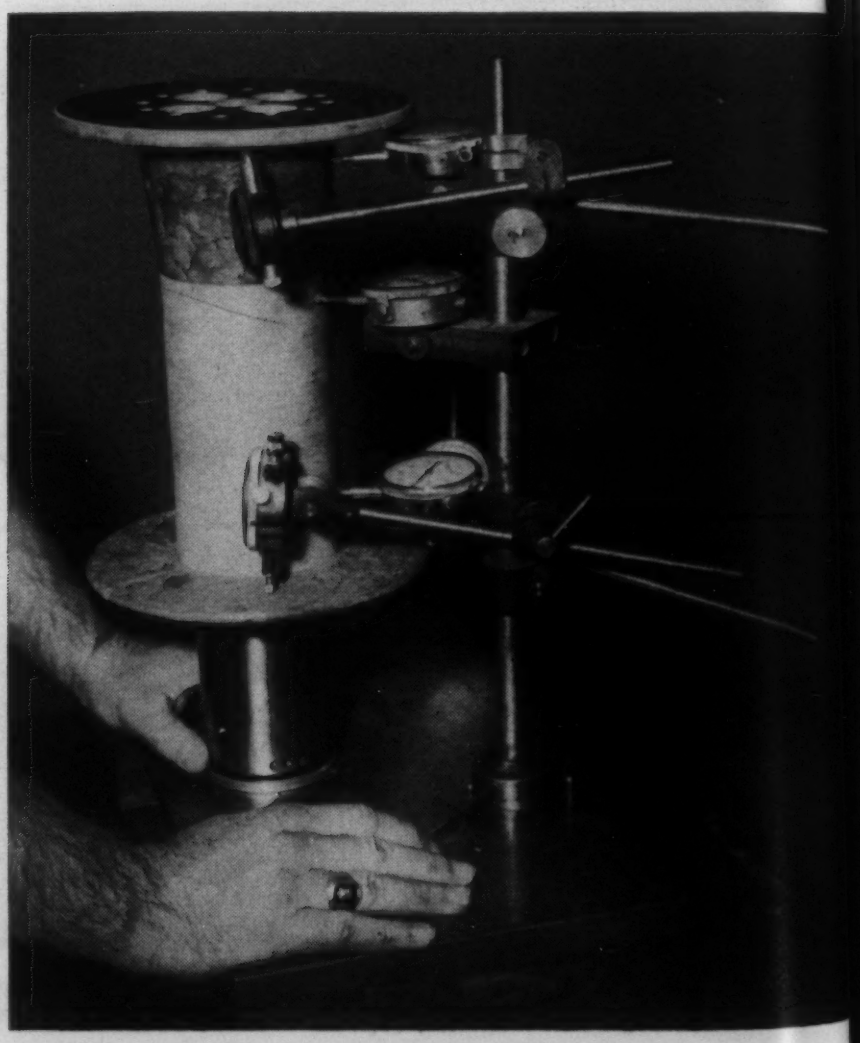
Bobbin's barrel is machined from grade XX paper base phenolic high pressure laminate tubing. The material was selected because of its ability—in relatively thin sections—to resist the high radial compressive forces of the shrinking nylon. Also the material has good machinability. Since concentricity of the barrel is essential for dynamic balance, the outer diameter is turned to accurate dimensions. To insure accurate dovetail fit with end of cone section, i.d. and end facing of barrel are also machined to accurate dimensions.



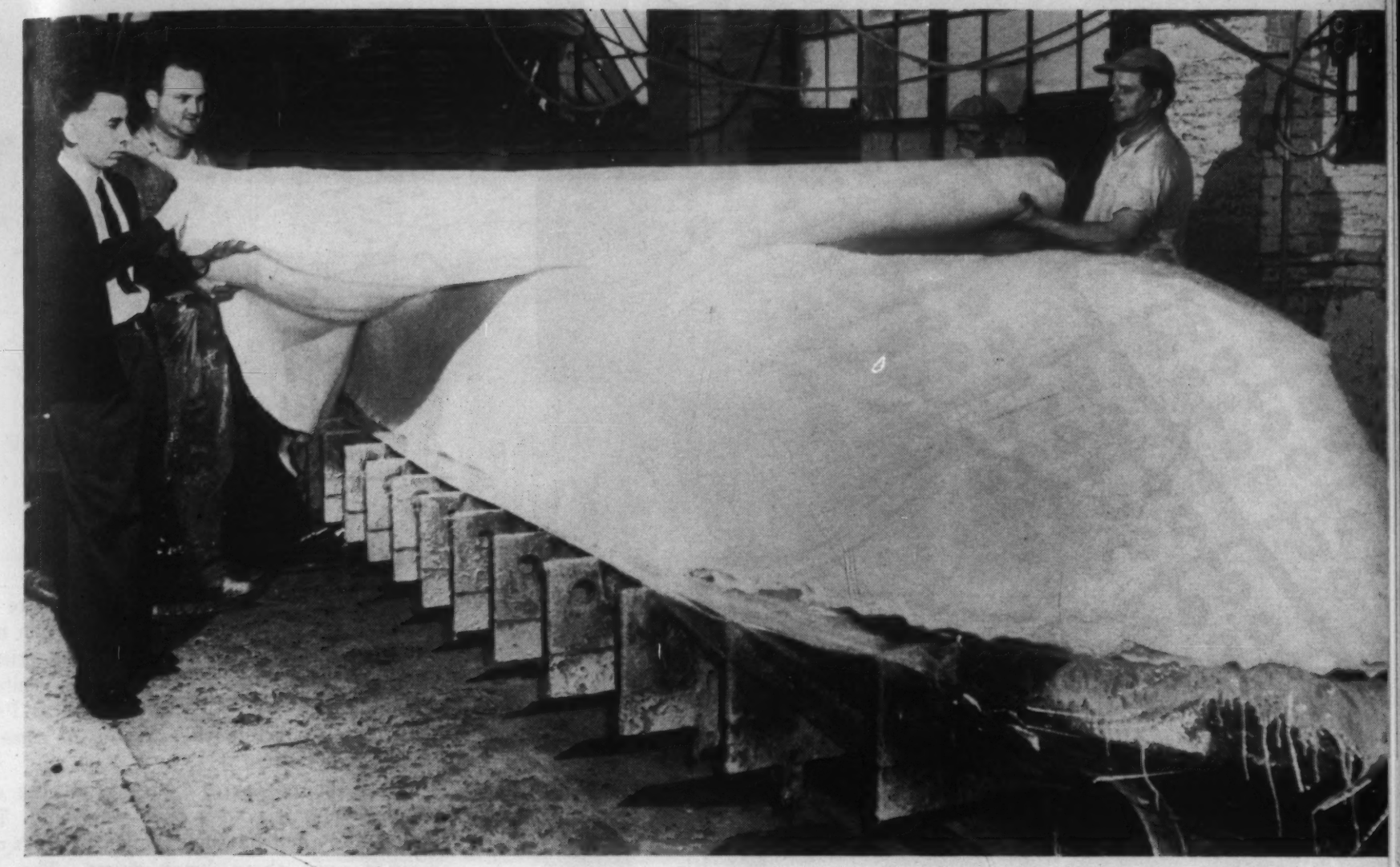
Cone section consists of a cloth-base phenolic macerated molding. A molding is used for this complex shape because of the substantial materials savings effected as compared with a machined shape. The cone has a hub which fits over the central steel clamping tube. It also has a stepped outer edge which fits into the barrel. These surfaces are machined simultaneously to ensure concentricity with spindle axis.



After end disk, barrel and cone bobbin are assembled they are locked together with center metal tub, the end of which is peened or turned over. Assembly is then rigidly clamped in special machine shown which precision bores the inside of the metal tube for accurate mounting on spindle. A slide then carries the two bobbins to the right where two boring tools produce accurate, concentric inside diameters at the lower end of the inner tube.



Accuracy and concentricity of the completely assembled bobbin is then checked by turning bobbin while gages contact critical areas. Bobbin is then checked for dynamic balance and small weights are added to correct any unbalance. Balance is corrected to 1/100 oz-in. at a speed of 1800 rpm.

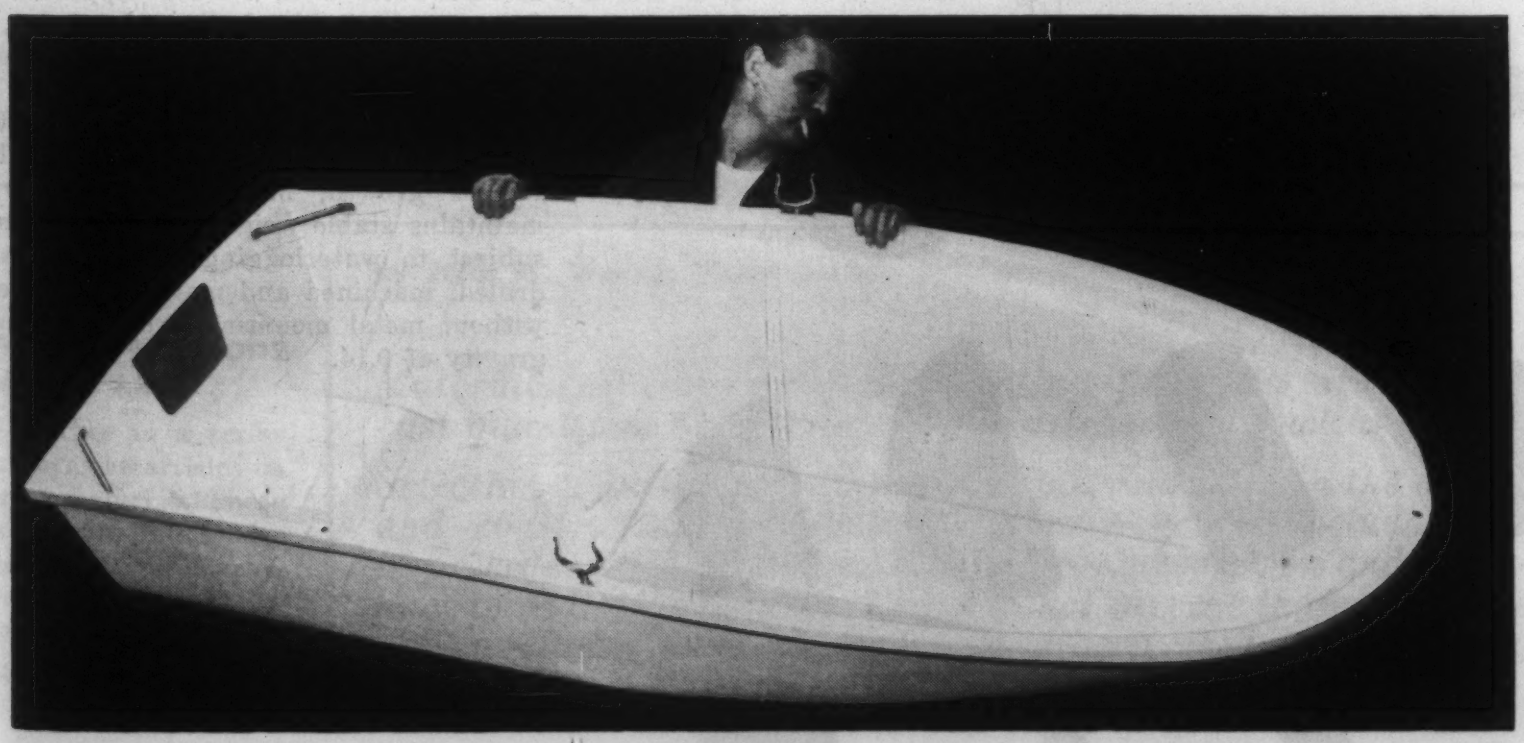


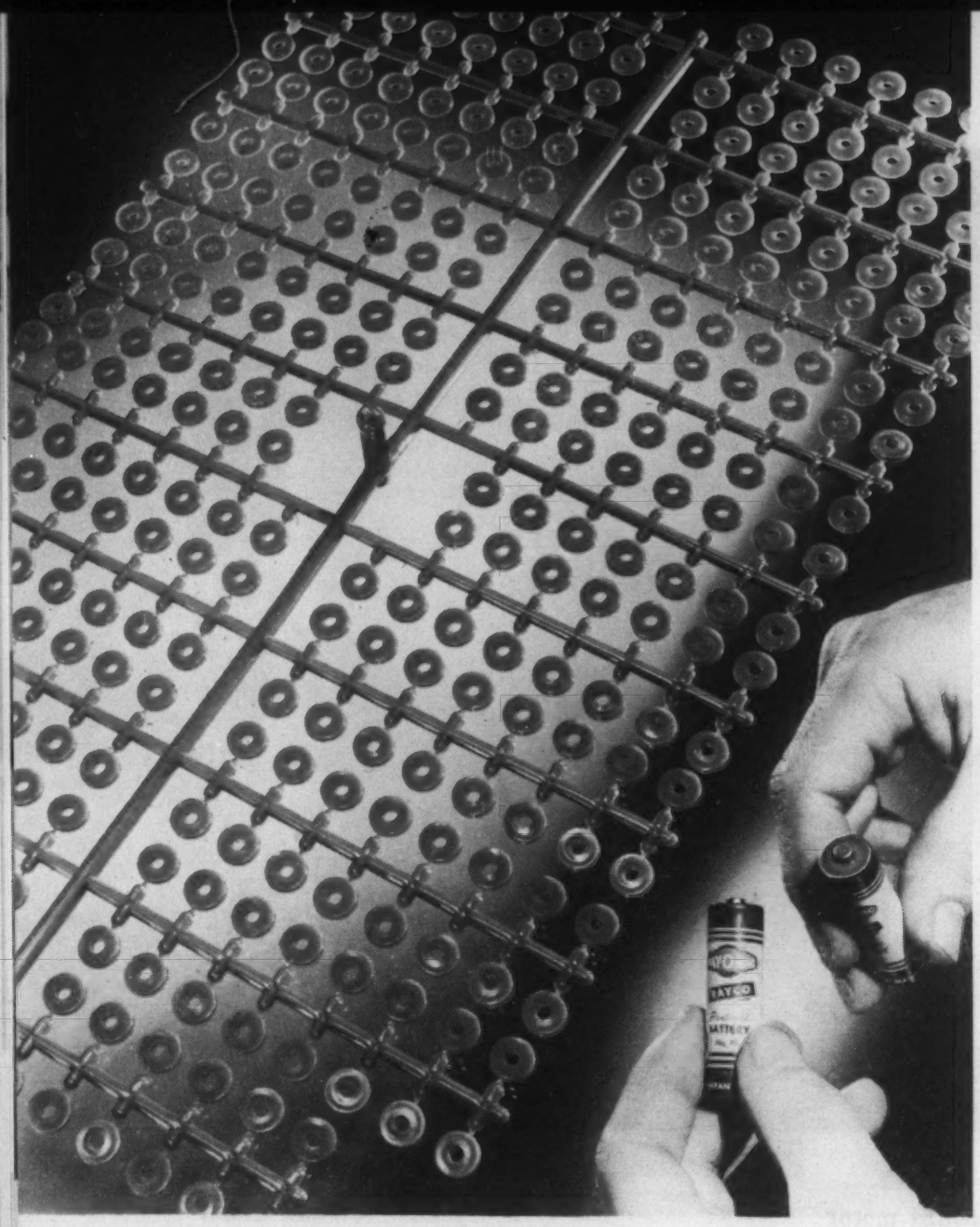
Improved plastics boat

An improved hull surface for a plastics outboard motor boat has been developed by Winner Mfg. Co. by using Du Pont's Orlon acrylic fiber. As shown in the above photograph, a needled batt of Orlon is placed over the glass fiber matt to reinforce the outboard surface. The plies are impregnated with polyester resin and the hull molded under heat and pressure. The mechanically bonded nonwoven batt of Orlon gives the hull a smooth surface and resistance to impact, abrasion, sunlight, water corrosion and microorganisms.

Fiberglass dinghy

This all one-piece fiberglass tender is nonsinkable. If swamped it has sufficient flotation to sustain two persons and a small outboard motor. Marketed by Aero-Nautical Boat Shop, Inc., it is 6 ft 10 in. long, weighs 35 lb, has a 42-in. beam and sealed in lengthwise seats.



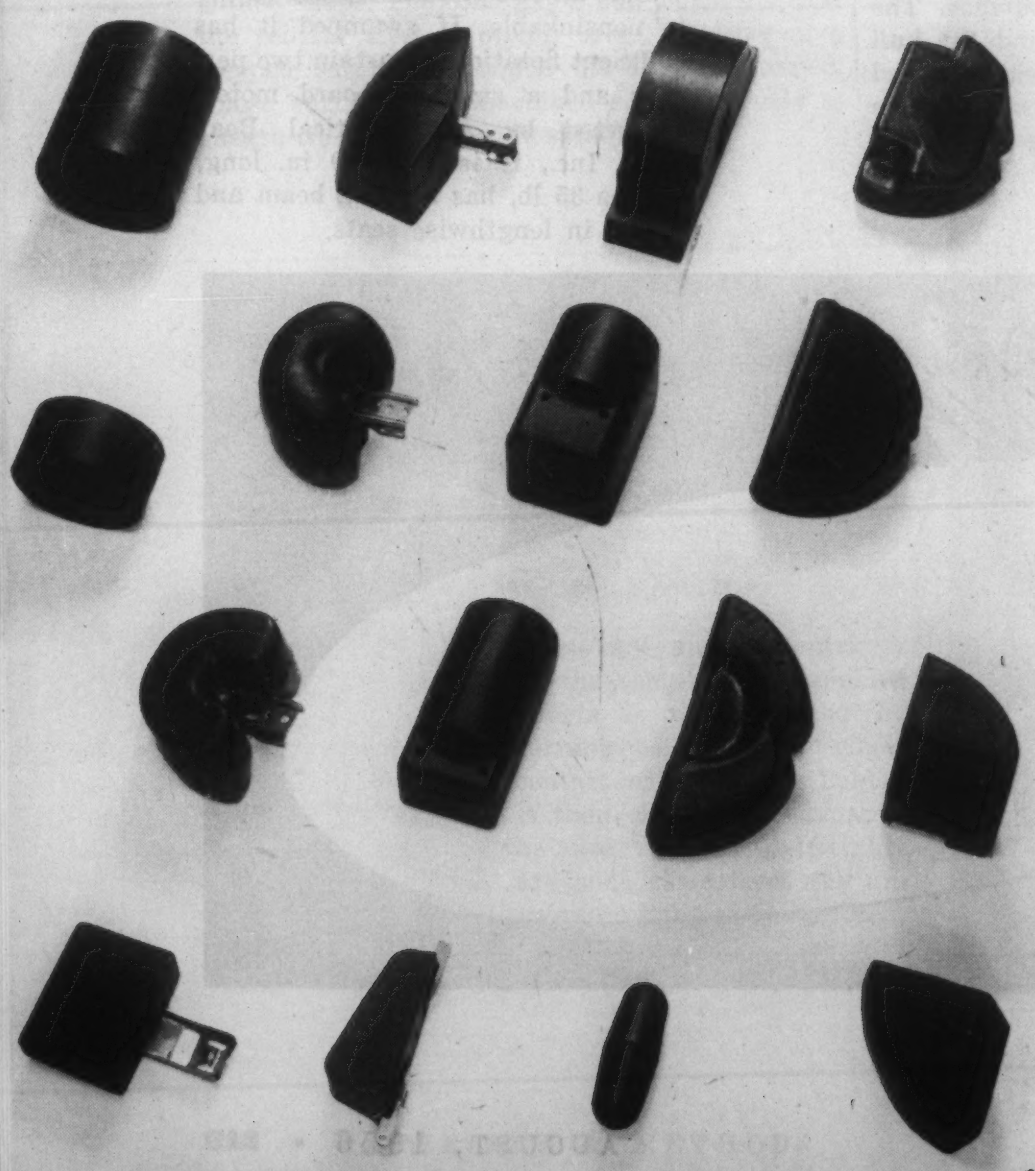


MATERIALS AT WORK

Polyethylene washers

Three hundred washers at a time are formed of red polyethylene by rapid injection molding for use as seals in pencil size batteries. The flow properties of the material, Tenite polyethylene made by Eastman Chemical Products, Inc., makes possible the casting of some 30,000 washers an hour.

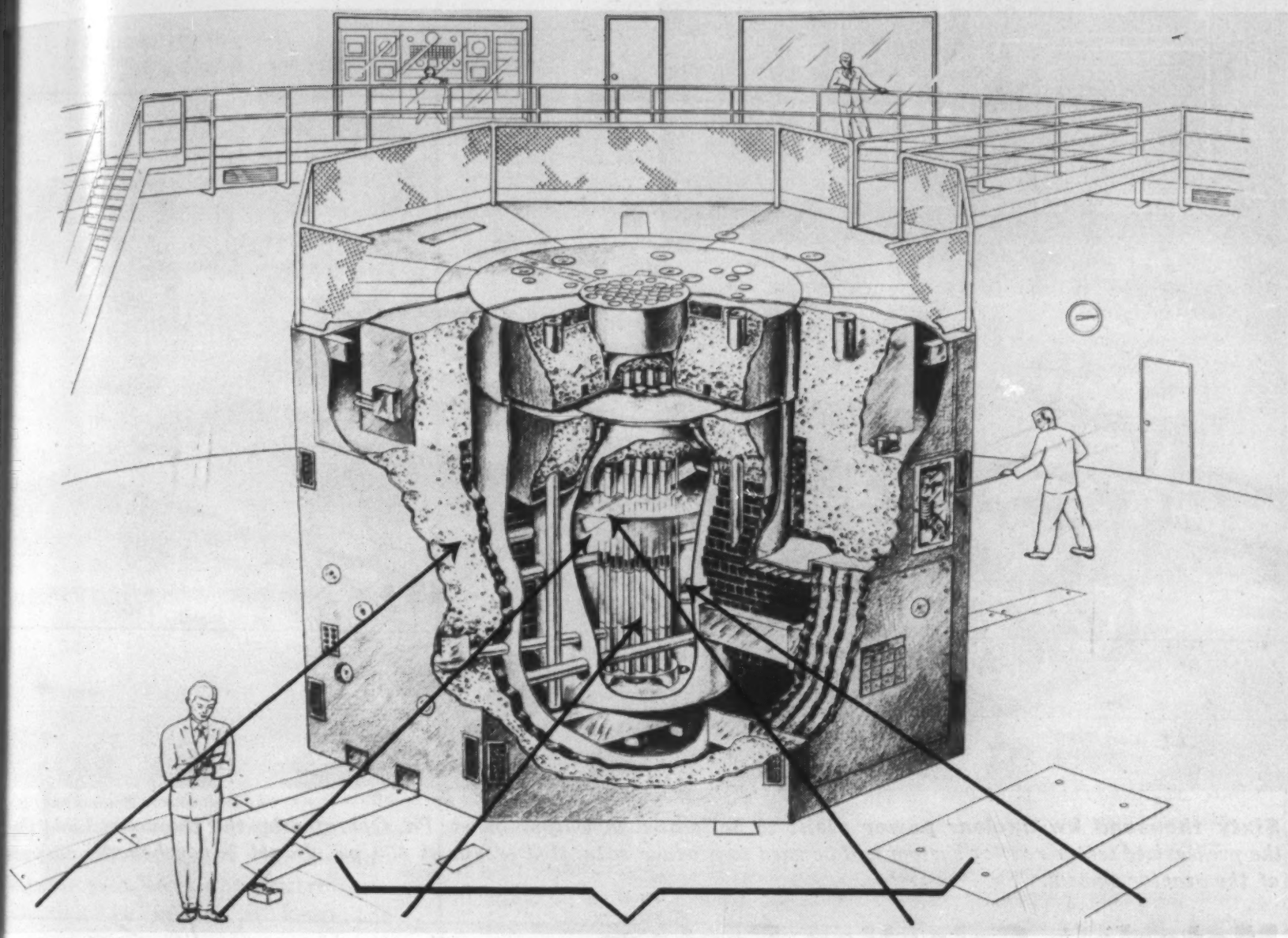
The washers strip easily from the over-all casting when it comes from the mold. They fit over the dry cell batteries with the cell's zinc cap crimped over their outer edges. The resilient washers make good insulators and will not break or corrode.



Unicellular rubber floats

Punctures and vibrations cannot affect floats of hard unicellular sponge rubber, made by Rubber Products Div., Parker Appliance Co. The floats are suitable for use in water, gasoline including aviation fuels, oil and other liquids over a wide temperature range.

Consisting of minute sealed cell structures, the material is lighter than cork. It resists fungus growth, needs no protective coating, maintains stable weight and volume and is not subject to waterlogging. The material can be drilled, machined and molded to shape with or without metal mounting arm. It has a specific gravity of 0.14.



SHIELDING	COOLANT	FUEL	STRUCTURAL		CONTROL	MODERATOR-REFLECTOR
water	water	uranium	aluminum	molybdenum	boron steel	water
cement and concrete	liquid metals	uranium ceramics	stainless steel	titanium	cadmium	heavy water
iron	sodium-potassium	thorium	nickel alloys	silicon carbide	samarium oxide	beryllium
lead	mercury	thorium oxide	zirconium	cermets	gadolinium oxide	beryllium oxide
tantalum	lead-bismuth		magnesium	plastics and elastomers	hafnium oxide	graphite
bismuth	gases					metal hydrides
boron	helium					
	nitrogen					
	carbon dioxide					

Materials for Nuclear Power Reactors

by John M. Warde, *Union Carbide and Carbon Corp.*

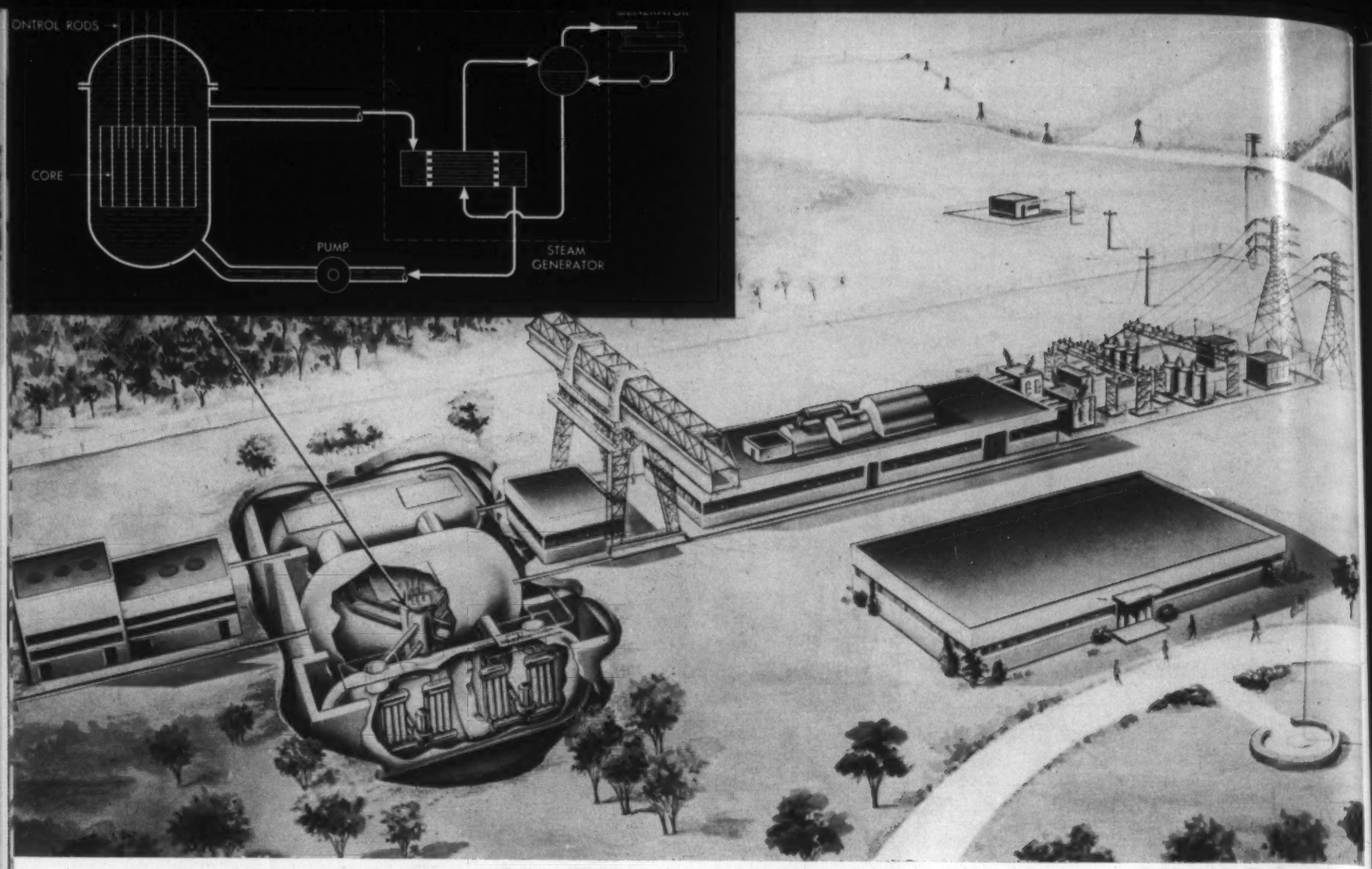
MATERIALS & METHODS MANUAL No. 129

This is another in a series of comprehensive articles on engineering materials. These sections provide the reader with useful data on characteristics and uses of materials, parts and finishes.

AUGUST 1956

Materials are currently the limiting factor in utilizng the vast quantities of thermal energy released by nuclear fission.

Selection criteria for engineering materials used in the design and construction of nuclear power reactors include such unprecedented demands as low neutron absorption and resistance to radiation damage. This manual surveys those materials now available that can be or have been used in harnessing nuclear energy for generation of power.



Combustion Engineering, Inc.

Sixty thousand kw nuclear power plant *to be located at Shippingport, Pa. Operated by the Duquesne Light Co., the pressurized water reactor system will be used to produce saturated steam at 600 psi. Insert is a schematic diagram of the reactor system.*

Materials Selection Factors

■ As in any materials selection problem, the choice of materials for nuclear reactor components is governed by the intended end use of the component. The construction of the reactor power plant requires the use of *structural materials* for the reactor framework, cooling systems, control mechanisms and remote handling facilities.

In addition to this general category of materials, the basic components within the reactor itself demand a special kind of materials selection. These units include the *shielding* to contain the dangerous radioactivity, the *control elements* to adjust the reactor power level, the *reflector* to scatter escaping neutrons back into the reactor core, the *moderator* to slow down fast neutrons to increase their probability of capture by the nuclear fuel, the *coolant* to remove heat from the reactor the *fertile material* (thorium 232, uranium 238) to absorb excess neutrons to produce new fuel, and the *nuclear fuel* (uranium 232, plutonium 239, uranium 235) to sustain the chain reaction.

The most important consideration in the selection of reactor materials is their neutron absorbing characteristics. Other factors which influence choice are heat transfer properties, susceptibility to radioactivity, corrosion resistance, radiation damage resistance, and ease of chemical processing. In addition, the selection criteria also include such engineering requirements as stability at operating temperature, low thermal expansion, high thermal conductivity, satisfactory mechanical strength under conditions of service, ease of fabrication, availability and reasonable cost.

Editor's Note

Engineering data on materials for nuclear use are expressed in the metric system. Presentation of materials data by this system has become traditional in the nuclear field. In this manual, therefore, we depart from our style of presenting engineering porperties in the fps system to conform with standard operating practice among nuclear engineers.

The reader will also note that the manual discusses nuclear fuels and coolants. These are not engineering materials in the traditional sense, and, therefore, would not normally fall within the editorial scope of MATERIALS & METHODS. However, the editors feel that for a comprehensive treatment of the problems inherent in reactor design and construction, the behavior of these materials in the reactor environment is basic to understanding the principles on which nuclear engineering is based.

Neutron absorption

Neutron absorption properties are inherent characteristics of elements and vary with the energy of the neutrons interacting with the nucleus of the element. They are expressed in terms of neutron absorption cross sections of the particular nucleus and are a measure of the probability that an incoming neutron will interact with the nucleus being bombarded, and be absorbed. The numerical designation of the absorption cross section is given in "barns" (1 barn=10^{-24} sq cm per nucleus).

Neutron absorption properties are a limiting factor in thermal reactors; however, they are less serious in intermediate and fast reactors as the cross sections generally decrease with increasing energies.

The need to conserve neutrons to sustain the chain reaction or produce new fuel makes it necessary to use only those materials in the active core of the thermal reactor that have low neutron absorption in order to keep the critical mass—the minimum quantity of fissionable material that will sustain the chain reaction—at a minimum. On the other hand, control rods that maintain the power level of the reactor by absorbing a portion of the neutrons being produced must be fabricated from material having a high degree of neutron absorption.

Nuclear requirements have introduced a new concept of purity into materials selections since the presence of even minor amounts of elements with a high neutron absorption cross section may rule out the material for service in the reactor core.

Radiation damage

The effects of nuclear radiation on the physical properties of reactor materials is a paramount problem. Physical changes in metals due to radiation exposure depend on atomic number, melting point and crystallographic structure.

Radiation exposure produces increased electrical resistance, hard-

How Thermal Reactor Works

Reactors are basically of two types, *homogeneous and heterogeneous*. In the homogeneous type the fissionable material or fuel is distributed uniformly throughout the active reactor, but in the hetrogeneous type it is localized in some form of structural unit. Reactors are further classified according to the energy of the neutrons used to produce the greatest percentage of fissions in the system. This division is into three general classes: *fast, intermediate* and *thermal*, in which the effective fission inducing neutrons have about 100,000, 1,000, or 0.1 electron volts of energy respectively. Reactors are also described according to their use as research reactors, production reactors, and power reactors.

Of the three general classes, thermal reactors are at present of principal interest for the production of nuclear power, although both the fast and intermediate reactors are also receiving attention for nuclear power production.

Fission

In a thermal reactor the energy is generated in the reactor core by the fission of the *fuel*, which is in solid or liquid form. To produce a chain reaction in a thermal reactor it is necessary to slow down the fast neutrons set free during fission so that they may be captured by other fissionable material nuclei. This slowing down process is brought about by surrounding the fuel with a material that has a low atomic weight and the property of scattering neutrons without absorbing them. Such a material is known as a *moderator* and in the case of many existing heterogeneous reactors, graphite is used for this purpose. Among the other materials suitable for such application are light and heavy water, beryllium metal and beryllia.

To increase the efficiency of the fission process a *reflector* composed of a material capable of reflecting neutrons back into the core is provided. Graphite is commonly used for this purpose in heterogeneous reactors and in some designs the moderator and reflector are combined as one component.

Heat removal

Removal of heat from the reactor core is accomplished by circulating a *coolant* or heat transfer medium through it at a rate sufficient to prevent the fuel from exceeding a safe operating temperature. Materials in use or under consideration as coolants include gases, such as air, CO_2 or helium and liquids in the form of water, molten salts or molten metals. In the case of power reactors, the coolant leaving the reactor might be passed through a heat exchanger that transfers the heat from the coolant to a separate thermal system where it may be used in the conventional manner for steam generation. If the coolant is a gas it may be supplied directly to a gas turbine.

Reactor control

For regulating purposes, *control rods* composed of high neutron absorbing substances such as cadmium or boron are used. The reactor and primary heat transfer cycle must be surrounded with materials that act as barriers to neutrons and gamma rays, which provide a serious health hazard. These barrier materials are known as *shields*. The bulk of the shielding in use at present is composed of hydrogenous materials, lead and concrete. In reactors employing the "breeding process," fertile materials, thorium 232 or uranium 238, are contained in structural units or are used in the form of slurry "blankets" and so located to produce new fuel by absorbing excess neutrons generated during fission.

For every gram of fissionable material expended, almost a gram of fission products is produced. Some of these fission products are high neutron absorbers and tend to "poison" the reactor, that is, reduce its reactivity. To correct this condition, the "poisoned" fuel must be periodically removed from the reactor for reprocessing.

MATERIALS APPLICATIONS IN POWER REACTORS

Reactor	Type[a]	Fuel	Fuel Elements	Cladding	Moderator Reflector	Coolant	Shield
OPERATING—PAST OR PRESENT							
APSI, Russia (30MW electricity)	T	5% enriched U-? alloy	Hollow tubes	Stainless steel	Graphite	Water	Water and concrete
Borax 1-2-3, Arco, Idaho (Argonne National Laboratory)	T	90% enriched U-Al Alloy	Plates	Aluminum	Water	Water	Concrete
Experimental Breeder Reactor (EBR), Arco, Idaho (Argonne National Laboratory)	FB	90% enriched U; Natural U	Rods	Stainless steel	Graphite	NaK[b]	Iron and concrete
IN ADVANCED DESIGN OR CONSTRUCTION							
Pressure Water Reactor (PWR), Shippingport, Pa. (60MW electricity) (Westinghouse-Duquesne Project)	T	Enriched U-Zr alloy; Natural UO_2	Plates, pellets	Zircaloy-2[c]	Water	Water	Concrete-earth
Calder Hall, Cumberland, England	T	Natural U	Rods	—	Graphite	CO_2	Concrete
Dounreay, Scotland	FB	Unspecified	Unspecified	Unspecified	—	Sodium or NaK	Concrete
Homogenous Reactor Test (HRT) Oak Ridge, Tenn.	FB	UO_2. SO^4 in Heavy water (90% enriched U)	—	—	Heavy water	Heavy water	Barytes gravel, water, concrete
Sodium Reactor Experiment (SRE) Santa Susana, Calif. (North American Aviation Co.)	T	2.8% enriched U	Rods	Stainless steel	Graphite canned in zirconium	Sodium	Concrete

[a] Type: T—thermal; FB—fast breeder
[b] Sodium (44%) potassium (86%) alloy
[c] Westinghouse designation, Zr—1.5% Sn.

ness and tensile strength. After exposure, metals have higher yield strength, lower percentage elongation and somewhat higher ductile-brittle transition temperatures. The amount of change is apparently smaller for cold worked than for annealed metals.

Plastics, unfilled, are badly affected by radiation; mineral-filled plastics such as those containing asbestos are much more stable. Organic lubricants and fluids are also subject to radiation damage. In general, polyphenal derivatives are more stable than hydrocarbons. Because of the radiation damage effects in organic compounds, inorganics are used wherever possible. Metal gaskets, seals and couplings are used in place of usual organics; graphite or molybdenum disulfide is used instead of conventional organic lubricants.

Ceramics are less resistant to the effects of severe irradiations than metals. There are indications, moreover, that in some ceramics these effects will "self-anneal." Radiation effects in ceramics are generally smaller at high temperatures and physical changes produced by irradiation will generally be removed at elevated temperatures.

Radiation damage data may be quoted in terms of integrated thermal flux, which is the product of the thermal flux (nv, where n equals the number of neutrons per cu cm, and v equals speed in cm per sec) and exposure time (t in sec).

NEUTRON ABSORPTION CROSS SECTIONS

	Ceramics	Melting Point, C	Metals	Melting Point, C
High[a]	Gd_2O_3	2300	Cd	321
	HfO_2	2810	B	2300
	—	—	Hf	1700
	—	—	W	3410
Intermediate[a]	TiO_2	1830	Ti	1800
			Ni	1452
	Cr_2O_3	2275	Cr	1615
	—	—	Mo	2620
	—	—	Fe	1535
Low[a]	Al_2O_3	2040	Na	98
	ZrO_2	2700	Al	659
	SiC	2200	Zr	1900
	MgO	2800	Mg	651
	BeO	2530	Bi	271
	C	—	Be	1350

[a] Low—up to 1 barn
Intermediate—1 to 9 barns
High—above 10 barns

Cladding

The fuel bearing core of the fuel system must be clad to protect the fuel from corrosion. The selection of cladding materials is governed by resistance to corrosion and measure of protection offered to the fuel. Diffusion between clad and core should be at

a minimum. The clad is either bonded to the fuel in which case it changes dimensionally with the fuel or it may contain a thermal bond such as liquid sodium between the fuel and the clad.

Bonded coatings of such alloys as aluminum-tin, zirconium-tin, or stainless steel are of present interest. Aluminum alloy clads are limited to low temperature operations below 200 C with water. Zirconium and zirconium alloys may be used at higher temperatures with 540 C as a probable upper limit. Stainless steel may be used up to 650 C or so and molybdenum has a probable use limit up to 1370 C in oxygen free atmosphere. Both iron base alloys and molybdenum, however, have relatively high thermal neutron absorption cross sections and could be used only with enriched fuel.

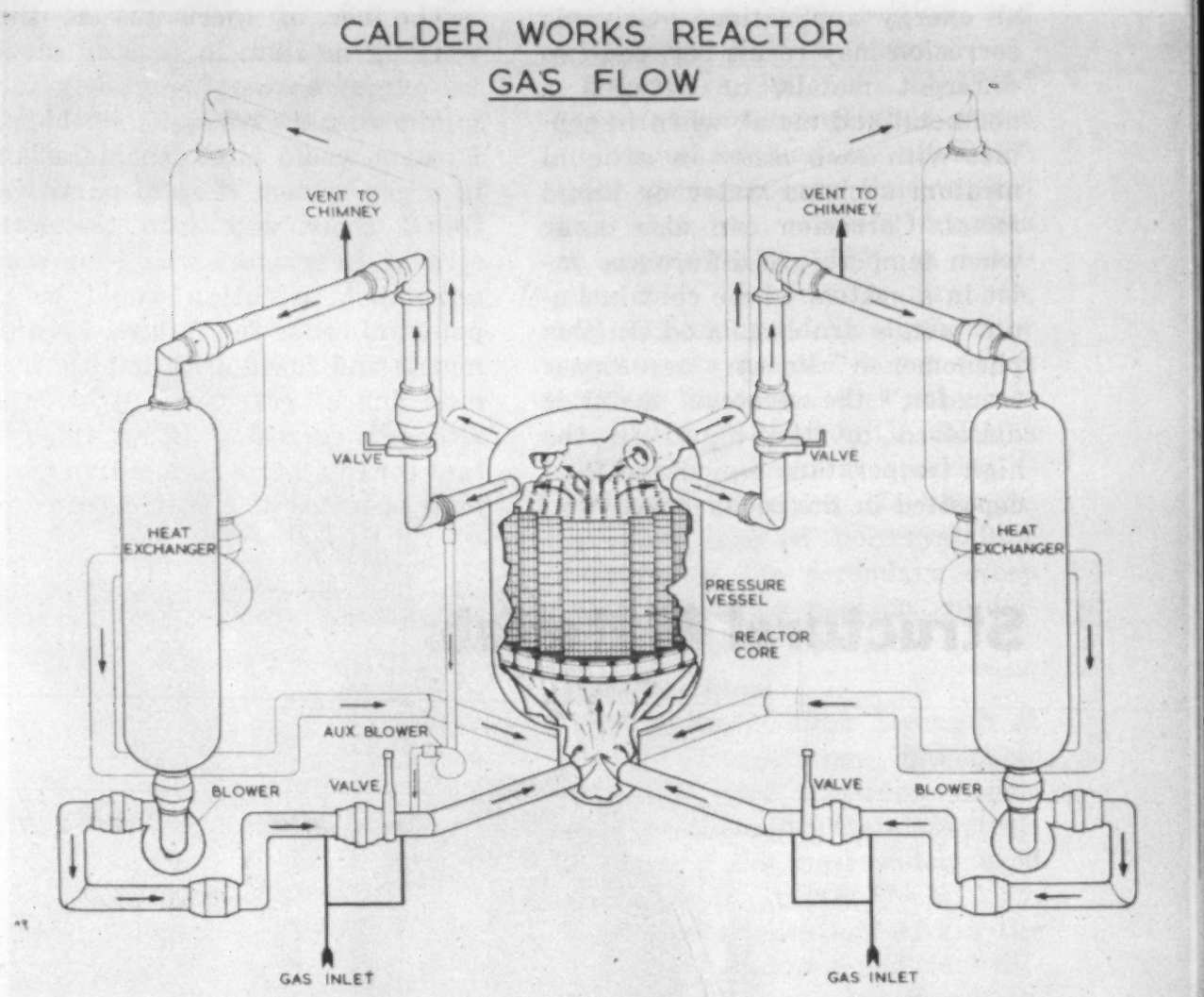
Heat transfer

Heat is liberated inside the nuclear fuel and passes outward in contrast to conventional chemical combustion where heat is applied to the outside and travels inward. For this reason, practical operation of reactors designed with high power densities impose a severe heat-removal problem. The solution is limited by the availability of materials with adequate resistance to thermal rupture.

Radioactivity

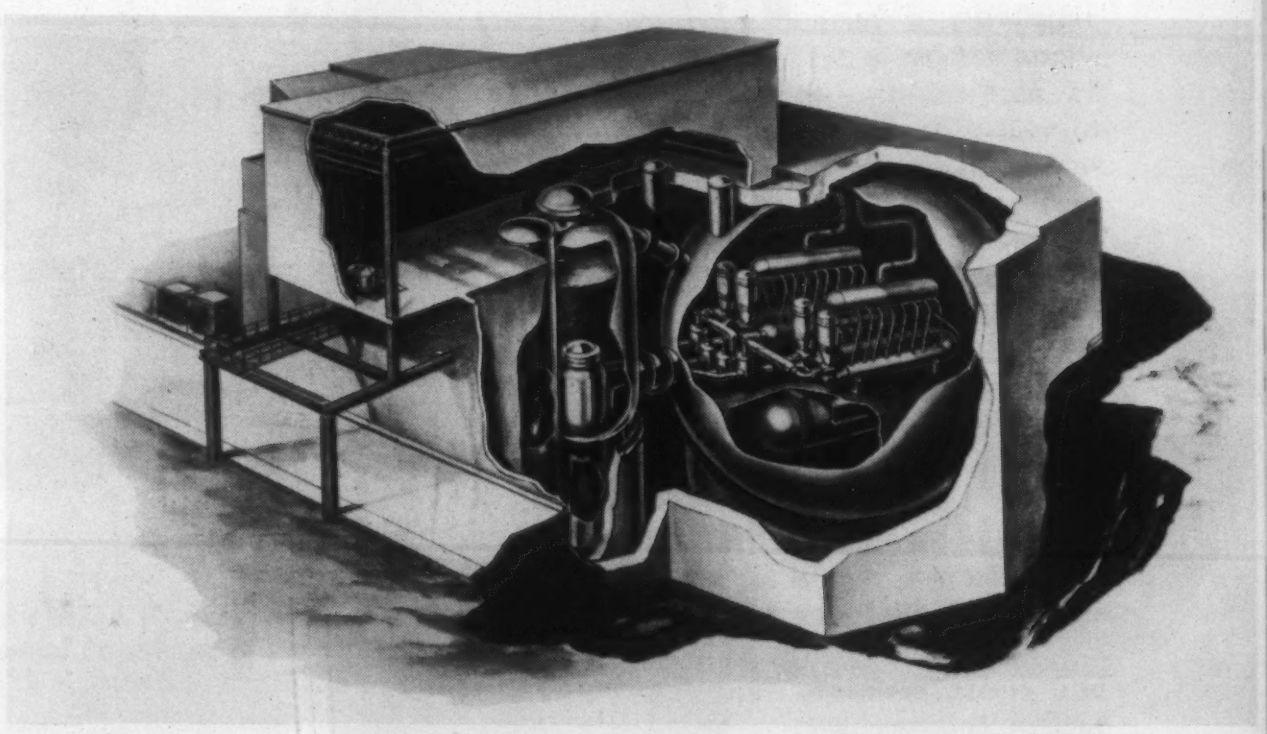
The problem of developing dangerous radioactivity in the reactor component materials as a result of neutron capture can pose serious difficulties in the maintenance and repair of materials exposed to a high neutron flux for an extended time. Therefore, preference is given to materials that do not become radioactive by neutron capture or develop only weak gamma-free radiation of short duration.

Among the principal elements that cause difficulty by induced radiation are chromium, manganese, cobalt, copper, zinc, tantalum and tungsten. While none of these is likely to be useful in pure form as a reactor material, they must be given consideration when they appear as alloying elements or impurities.



United Kingdom Atomic Energy Establishment

Gas cycle power reactor *being constructed at Calder Hall in England. Reactor uses carbon dioxide as the coolant.*



Babcock & Wilcox Co.

This internal thorium convertor type reactor *will generate 236,000 kw. Planned by Consolidated Edison Co., it will be located at Indian Point, N. Y., and will be moderated and cooled with water.*

Corrosion

Major problems of corrosion and erosion resistance arise in many reactor designs as materials are considered for use in the new environments accompanying nucle-

ar energy applications. Galvanic corrosion may result between two different metals, or between a nonmetal and metal, when in contact with each other in a liquid medium such as water or liquid metal. Corrosion can also occur when temperature differences exist in a system where certain liquid metals are circulated. In this phenomenon known as "mass transfer," the structual metal is dissolved by the liquid in the high temperature region and then deposited in the cooler zone.

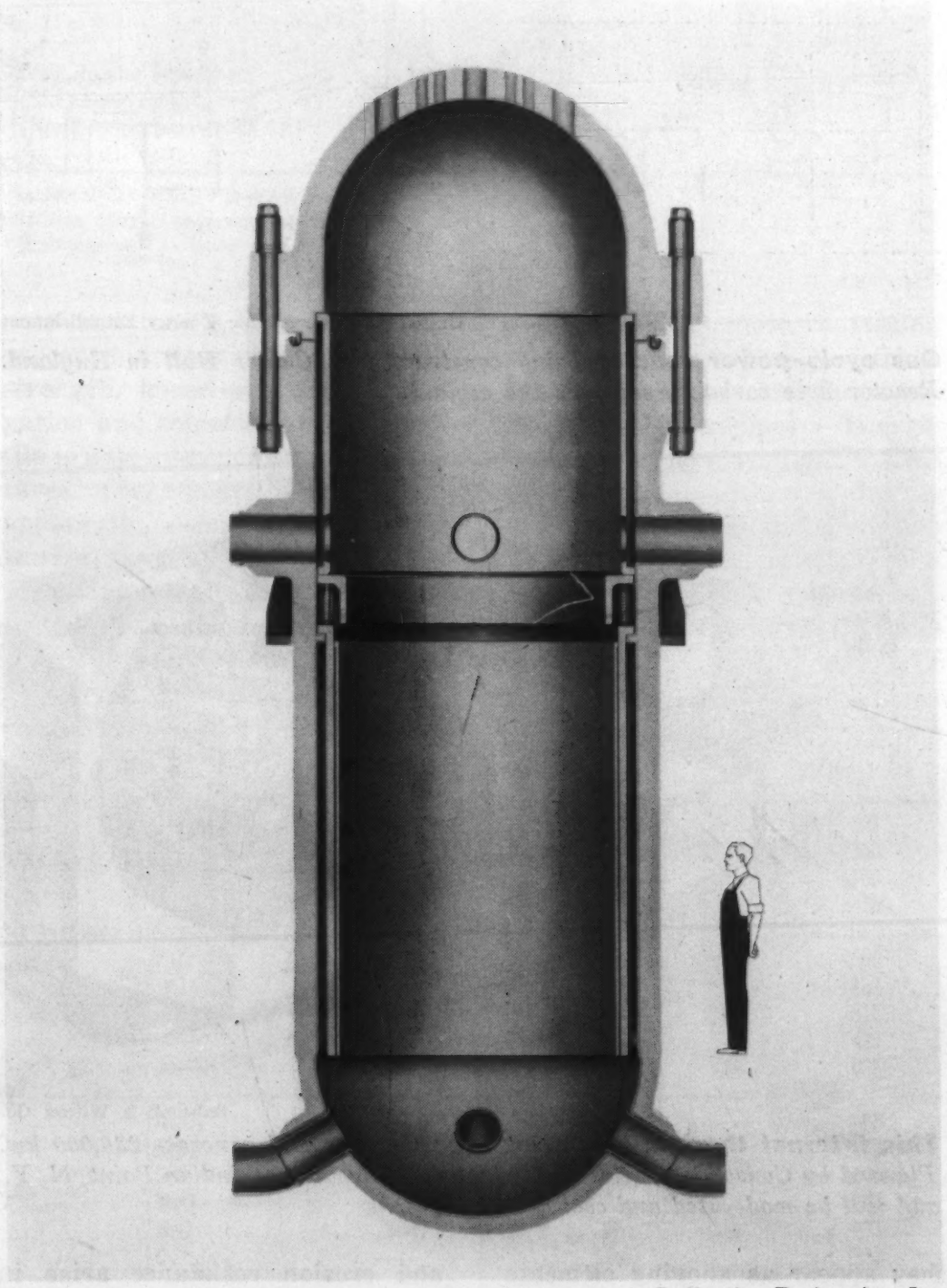
The use of inert gas as the working medium in reactor service offers the best possibility for minimizing the corrosion problem. Erosion would be a consideration in a gas system if solid particles found their way into the gas stream. In reactors where air was circulated, oxidation would be a potential cause for failure. Liquid metals and fused salts impose the most difficult corrosion conditions, although corrosion is an important consideration in aqueous systems operated at elevated temperatures and pressures.

Corrosion rates may be altered by irradiation, and this factor must also be considered in evaluating the corrosion resistance of materials intended for reactor service.

Chemical processing

The character of a material selected for fuel elements or fertile materials must be such that it is amenable to chemical processing to reclaim the valuable fissionable materials after they have been removed from the reactor.

Structural Materials



Combustion Engineering, Inc.

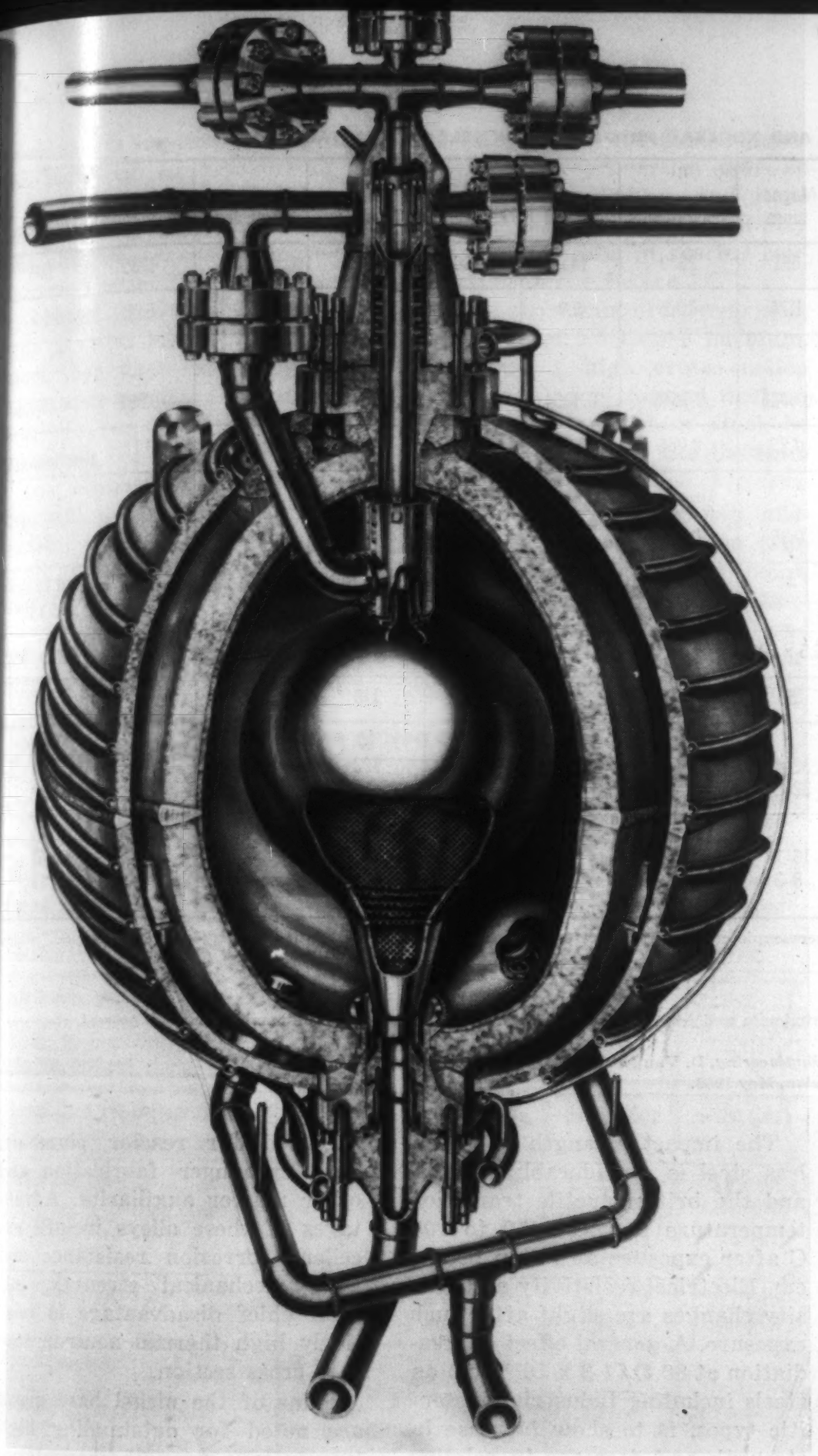
Shippingport reactor *stands more than 30 ft tall and weighs approximately 230 tons. Head of vessel is removable to permit reloading reactor.*

Structural materials used within the reactor must be selected on the basis of low neutron absorption characteristics as well as for their physical and chemical properties. The neutron absorption requirement severely limits the choice of materials. Those of major interest are stainless steel, aluminum, zirconium and nickel base alloys. Some ceramic materials with suitable characteristics have potential applications for the structural components of reactors where the load bearing properties at elevated temperatures are required. Those of principal interest are alumina, magnesia, beryllia, silicon carbide and zirconia.

Aluminum

Aluminum, generally in the relatively pure 1100 form, has been widely used in reactor service for cladding fuel elements. It has also been employed as a structural material and for other applications. Aluminum has low neutron absorption characteristics, satisfactory resistance to low temperature aqueous corrosion, excellent heat transfer properties and is readily available at reasonable cost. Its low melting point and strength limit its use to low temperatures.

Because of low neutron absorption cross section and good corrosion resistance casting alloys are attractive. In designs requiring better performance at moderately



Oak Ridge National Laboratory

HRT reactor vessel assembly *has an inner core vessel of 32-in. i.d. fabricated of 5/16-in thick Zircaloy 2. Pressure vessel surrounding the core has a 60-in. i.d., fabricated from 4-in. ASTM A212-54a T carbon steel clad with 0.4-in. 347 stainless steel. Blast shield measures 74 in. i.d. and is made of 1½-in. 304 stainless steel.*

elevated temperatures, at some expense to neutron economy certain of the copper bearing alloys may be of interest. Wrought alloys also offer useful possibilities. Included in this class are the comparatively pure alloys 1100 (which has been used extensively as a full clad) and 3003; the high strength copper bearing alloys 2017 and 2024; medium strength alloys 6061 and 6063, which possess good corrosion resistance and low thermal cross section; and 5052, a strain hardenable alloy with good forming characteristics, low thermal neutron cross section and good corrosion resistance.

The alloys 1100, 5052, 6061 and 5154 show increased yield stress and decreased ductility after 10^{21} n per sq cm exposure. Cold worked 1100 aluminum exhibits increases of approximately 15% in hardness, 26% in ultimate strength, and 22% in yield strength after exposure to 2×10^{20} n per sq cm at 30 C. Radiation does not cause hardening at 250-300 C, which is above the aluminum recrystallization temperature. No changes in creep rate of polycrystalline alumina in the secondary creep range caused by neutron irradiation have been found.

Stainless steel

By virtue of their strength at elevated temperature and their generally good corrosion resistance the austenitic stainless steels are among the most widely used materials in reactor technology. They find application within the reactor as cladding and fuel diluents and for reactor plumbing. They are also important choices as construction materials for heat exchanger and other auxiliary reactor components.

The selection of a particular stainless steel for a reactor application requires consideration of such problems as susceptibility to intergranular corrosion of unstabilized stainless steels after sensitizing heat treatments; stress corrosion cracking; formation of a beta sigma phase particularly with high ferrite weld deposits that are frequently used to avoid weld type cracking; knife line corrosion attack; high thermal stress due to poor heat conductivity; and accelerated corrosion produced by highly corrosive rapidly flowing solutions due to the removal of protective films.

Type 347 stainless steels and type 304 L (low carbon) are of interest where intergranular attack of the sensitized material may be expected or field welding precludes annealing. Type 304 may be useful if the environment is such that intergranular attack of the sensitized stainless steel is unlikely to occur or if the welding

PHYSICAL AND NUCLEAR PROPERTIES OF SELECTED METALS[d]

Properties	Aluminum	Beryllium	Magnesium	Molybdenum	Nickel	Tantalum	Titanium	Tungsten	Vanadium	Zirconium
Melting Point, C	660.2	1280	651	2620	1455	2996	1725	3410	1735	1845
Bulk Density, gm/cm³	2.7	1.85	1.74	10.2	8.9	16.6	4.5	19.3	6.02	6.5
Thermal Neutron Absorption Cross Section, cm²/cm³[a]	0.0129	0.0012	0.0025	0.1540	0.4094	1.1786	0.315	1.2159	0.331	0.007735
Spec Ht, cal/gm/C	0.22	0.5	0.25	0.065	0.11	0.036	0.129	0.034	0.12	—
Thermal, Cond, (cal/sec/cm²/C/cm)	0.54	0.3	0.35	0.346	0.14	0.130	—	0.476	—	0.05
Coeff of Exp, per C	24×10^{-6}	12×10^{-6}	—	5.5×10^{-6}	13×10^{-6}	6.5×10^{-6}	8.5×10^{-6}	4.0×10^{-6}	—	10.3×10^{-6}[b] 4.5×10^{-6}[c]
Mod of Elast, psi	10×10^6	42×10^6	6.5×10^6	$40–50 \times 10^6$	30×10^6	27×10^6	16.8×10^6	$50–60 \times 10^6$	$20–22 \times 10^6$	12×10^6
Brinell Hardness	20–25	110–150	50	147	75	75–125	110	260	260	—
Ten Str:					47	50	80	50	—	35
Annealed, 1000 psi	13	45	32–46	100	125	125	122	300	—	85
Cold Worked, 1000 psi	24	—	32–50	250						
Elongation in 2 in. (%):										
Annealed	85	1–2	16–12	10–20	15	40	24	—	—	31
Hardened	5	—	8–3	2–5	3	1	7.5	—	—	18

[a] The total area of nuclei per cu cm is called "macroscopic cross section," referring to bulk area, in contrast to "microscopic cross section," which has to do with individual atomic absorption.
[b] Direction of the hexagonal axis.
[c] At right angles.
Note: Values for mechanical properties are approximate and can vary considerably depending on heat treatment, impurities present, etc.
[d] *Metals Handbook*, ASM, 1948.
Samuel Gladstone, *Principles of Nuclear Reactor Engineering*, D. Van Nostrand Co., Inc., New York, 1955,
Reactor Handbook, U. S. Atomic Energy Commission, May 1955.

is not required (or if welds can be given a full anneal above 1000 C followed by fast cooling to avoid sensitization).

Austenitic stainless steels have a wide variety of applications in reactor service because of their general good corrosion properties and high temperature performance. The stabilized class such as AISI 321 or 347 are of special interest because of their resistance to intergranular corrosion.

In contrast to other metals—molybdenum, tantalum, titanium, zirconium and tungsten—stainless steels show excellent oxidation resistance in air up to 900 C or higher. Compared with zirconium, stainless steel has somewhat lower corrosion resistance at moderate temperatures and larger neutron absorption characteristics, but it has generally better strength properties at elevated temperatures.

The impact strength of stainless steel is considerably lowered and the brittle ductile transition temperature is raised 50 to 100 C after exposure at 10^{19} n per sq cm. Electrical resistivity and density changes are slight after such exposure. A general effect of irradiation at 80 C (1-3 x 10^{20} nvt) on steels including industrial austenitic types, is to show increase in strength and decrease in relative elongation. Increased hardness of the order of 10% is characteristic of the Type 347 stainless steels under these exposure conditions. At an exposure of 10^{20} n per sq cm the yield strength of stainless steel is close to ultimate strength and no marked change in Young's modulus is observed up to 5 x 10^{18} n per sq cm.

Nickel and nickel base alloys

Nickel alloys for nuclear energy applications are Inconel X, Nimonic 80 and Nimonic 90. They can be used for reactor plumbing, heat exchanger fabrication and other reactor auxiliaries. Advantages of these alloys include excellent corrosion resistance and good mechanical strength, but their chief disadvantage is relatively high thermal neutron capture cross section.

Some of the nickel base alloys are noted for outstanding high temperature strength characteristics. They are exceptionally tough and their room temperature mechanical properties are of the same order as hardened steel. Their corrosion resisting properties are good in air, in liquid sodium, potassium and sodium-potassium alloys and in caustic media. Some are particularly resistant to the attack of mineral acids and halogen compounds.

Nickel exhibits no increase in thermal conductivity in in-pile measurements. Under radiation,

hardening is improved and grain size increases. At exposure of 2 x 10^{20} n per sq cm at 180 C, hardness increases more than 120% and ultimate tensile strength is increased better than 50%. Creep rate shows little change at 700 C with a beam loaded with maximum fiber stress of 141 kg per sq cm upon exposure to a dose of 3 x 10^{11} n per sq cm per sec.

Zirconium

Low neutron cross section, exceptional corrosion resistance in certain environments and relatively high strength at moderately high temperatures make zirconium one of the better materials for constructional and fuel cladding functions in thermal reactors operating up to 400 C. Corrosion and strength properties may be improved by alloying, and it is probable that such alloys will play an important role in reactor construction in the future.

Since zirconium ores invariably contain from 0.5 to 3% hafnium, which has a high cross section (115 barns) for thermal neutron capture, the zirconium must be processed to reduce the hafnium content.

Zirconium exists in two allotropic forms between room temperature and its melting point. The alpha form (close packed hexagonal) is stable up to 863 C and the beta form (body centered cubic) is stable above this temperature. The alpha form can be prepared in ductile form with machining and mechanical properties similar to plain carbon steel.

The nature and treatment of the metal affect its physical properties, e.g., thermal expansion and conductivity. Anisotropic behavior is noted in both single crystals and in rolled products.

Resistance of relatively pure zirconium and certain alloys, in particular those containing tin, to corrosion in air, water or steam at temperatures up to 400 C is excellent. Above this temperature zirconium reacts more readily in these media and also loses some of its strength. Its usefulness as a structural component is probably limited to lower temperatures.

The mechanical properties of zirconium vary widely with the nature of the metal and trace impurities present. In general, however, tensile strength, yield strength and creep strength all drop off with increasing temperature. Alloying with aluminum, tin, molybdenum and columbium has been reported to improve this condition.

Zirconium can also be fabricated by powder metallurgical methods. Zirconium is first converted to the brittle hydride for reduction to powder after which it is decomposed on heating in vacuum to yield zirconium powder. The metal powder may be compacted at a pressure of 50 tons per sq in. and sintered in an inert atmosphere or in vacuum. Material so prepared is hard, ductile and can be cold rolled.

Alloys have been prepared containing 1.5% or less of tin that show promise of improving corrosion resistance and are of adequate strength. The resistance of zirconium to attack by such liquid metals as sodium and sodium-potassium alloys is of particular importance for reactor technology.

About 75% of the tensile property changes caused by reactor exposure at 50 C are removed by annealing for 100 hr at 250 C. For comparable recovery of cold worked samples a higher annealing temperature is necessary.

PROPERTIES OF SOME CERMETS[d]

Properties	Silicon Carbide-Silicon	Chrome-Alumina	Chrome-Alumina	Titanium Carbide-Nickel[a]
Composition, %	80SiC-2C-18Si	72Cr-28Al_2O_3	30Cr-70Al_2O_3	80Ti-20Ni
Max Long Time Service Temp, C	1400	1300	1300	1200
Bulk Density, gm/cm^3	3.1	5.95	4.68	5.8
Thermal Neutron Absorption Cross Section, cm^2/cm^3	0.00659	0.147	0.056	0.311
Thermal Cond, cal/sec/cm^2/C/cm	0.5 (50C) 0.06 (1000C)	0.04 (20C)	0.023 (20C)	0.080 (20C)
Coeff of Exp, per C	4.2 x 10^6 (20C)	5.85 x 10^6 (25-800C)	8.65 x 10^6 (25-800C) 9.45 x 10^6 (25-1315C)	5.0 x 10^6 (25-1000C)
Young's Mod, psi	35.8 x 10^6 (20C)	47.2 x 10^6 (25C)	52.3 x 10^6 (25C)	56.7 x 10^6 (1000C)
Spec Ht, cal/gm/C				
400C	0.228	—	—	—
700C	0.252	—	—	—
1000C	0.267	—	—	—
Preferred Methods of Fabrication[b]	Impregnation of formed C or SiC with Si	I, III, IV	I, III, IV	I, III, IV
Possible Thermal Reactor Application[c]	F-S	F-S	F-S	S

[a] Kennametal K-515a
[b] Fabrication No.:
I—Cast and sintered
II—Extruded and sintered
III—Cold pressed and sintered
IV—Hot pressed
[c] Application Code:
F—Fuel elements
S—Structural parts
[d] Source: "Refractories for Nuclear Energy," American Refractories Institute Technical Bulletin No. 94, Feb 1956.

Creep shows a marked increase after exposure of 3 x 10^{12} n per sq cm per sec (less than 0.5 Mev.) In impact tests conducted at –78 C on samples exposed to 3 x 10^{19} n per sq cm less than 1 Mev, the energy to fracture increased 200%; subsequent irradiation to 6 x 10^{19} n per sq cm reduces it to the preirradiation value.

Magnesium

The low thermal neutron cross section of magnesium and its relatively high strength-to-weight ratio make magnesium another material of potential value in reactor material. It has good machinability and is readily cast and fabricated by conventional processes. It is normally alloyed with other metals such as aluminum, zinc and zirconium to obtain higher structural strength. The major limitations of magnesium for reactor use are its low melting point and limited corrosion resistance in water above room temperature.

Molybdenum

The high melting point (2622 C) and generally good mechanical properties and ductility of molybdenum above 1000 C make it of potential interest as a reactor

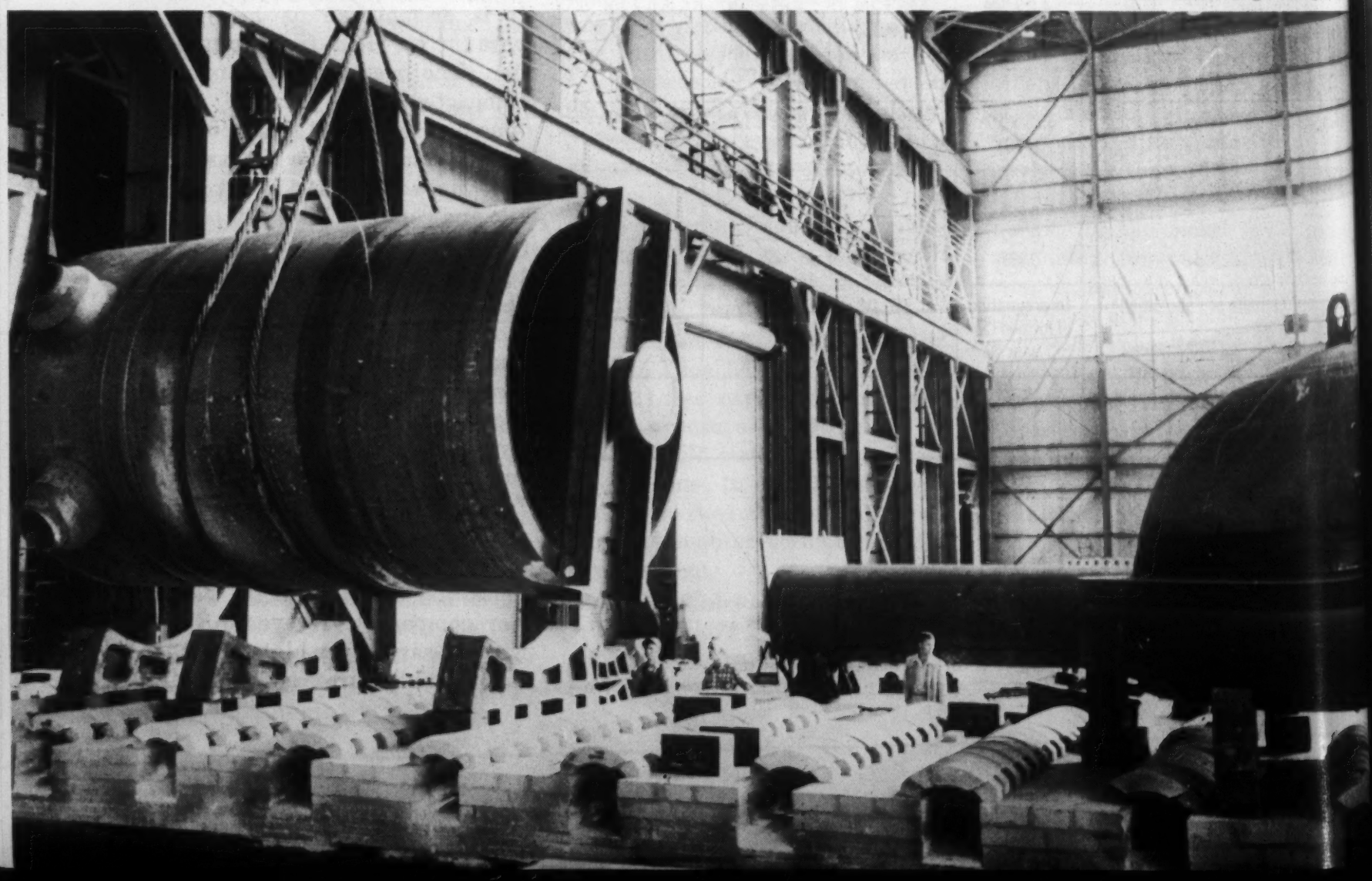
RADIATION STABILITY OF SELECTED PLASTICS[b]

Plastic	Exposure[a] (nvt)	Radiation effects
Mineral-filled Furan and phenolics: Duralon, Haveg 41, asbestos fiber Bakelite, asbestos fabric Bakelite, and Karbate	10^{19}	Little change except for darkening
Styrene polymers: Amphenol and Styron 411C	10^{19}	Little change except for color darkening
Modified styrene polymer: Styron 475	10^{19}	Impact strength and elongation decreased until the same as unmodified polystyrenes
Aniline formaldehyde (cibinite) and polyvinyl carbazole (Polectron)	10^{19}	Tensile strength decreased slightly
Polyethylene and nylon	10^{19}	Impact strength decreases but tensile strength increases. Becomes very brittle
Mineral filled polyester: Plaskon Alkyd	10^{19}	Impact strength and tensile strength decrease about 50%
Unfilled polyesters: Selectron 5038 and Cr-39	5 x 10^{18}	Develops small cracks. Impact strength and tensile strength decreased
Phenolics with cellulose fillers: paper base Bakelite, linen fabric Bakelite, Micarta	3 x 10^{18}	Becomes brittle, swells and decreases in tensile and impact strength
Melamine and urea: Melmac, Beetle, Plaskon Urea, and Plaskon Melamine	2 x 10^{18}	Tensile strength and impact strength are decreased about 50%
Unfilled phenolic: Catalin	1 x 10^{18}	Tensile strength and impact strength decreased about 50%
Vinylidene chloride (Saran B115) and vinylchloride acetate (Vinylite)	5 x 10^{17}	Soften, blacken, evolve HCl and decrease in tensile strength
Casein (Ameroid), methyl methacrylate (Lucite), Teflon, Fluorothene, and the celluloses; cellulose nitrate (Pyralin), cellulose acetate butyrate (Tenite 11), cellulose propionate (Forticel), and ethyl cellulose (Ethocel R-2)	10^{17}	Tensile strength and impact strength decreased about 50%

[a] Integrated thermal flux (product of flux and the exposure time).
[b] Source: O. Sisman and C. D. Bopp, Report ORNL—928, 1954.

Reactor vessel and head *for Shippingport are shown being loaded into annealing furnace. Vessel body is made of stainless-clad carbon steel and measures about 8½ in. thick.*

Combustion Engineering, Inc.



construction material for high temperature service under nonoxidizing conditions. Its major drawback is its ready oxidation in air above about 400-500 C. Molybdenum has a relatively low thermal neutron absorption cross section and it can be readily fabricated and machined under proper conditions. Satisfactory brazing techniques are available, but welding is more difficult although developments in this field show promise. Alloys have been developed that indicate possible improvement of high temperature mechanical properties.

Titanium

The relatively high thermal neutron capture cross section of titanium has restricted its consideration for use in thermal reactors. It may be of interest for intermediate or fast reactors because of its excellent combination of mechanical strength and corrosion resistance. It is ductile and readily fabricated, and resists oxidation in air up to around 700 C for extended use (1000 hr test). It is stable against stress corrosion cracking up to about 95% of yield strength.

Ceramics

Present reactors operate at temperatures well within the service range of selected metals. Consequently, ceramics are not used in existing reactors for their heat resisting properties. The desire to reach higher temperatures in order to improve thermodynamic efficiency has, however, stimulated much interest in high temperature ceramics and considerable research is being carried out.

Ceramics are being considered as materials of construction for all of the following basic reactor components: fuel elements, moderators, reflectors, control devices, shielding and structural materials. Those receiving major attention for nuclear energy use include the pure oxides, graphite, carbides and the silicides.

Refractory oxides such as BeO, Al_2O_3, MgO, and ZrO_2, when pure, show good resistance to oxidation and have high strength at elevated temperatures. Their application is limited, however, by reason of their brittleness and a low order of resistance to thermal fracture. Many carbides are extremely stable and highly refractory. They are hard, possess fair thermal and electrical conductivity, but have limited resistance to

PROPERTIES OF SOME CERAMIC OXIDES[d]

Properties	Alumina	Beryllia	Gadolinia	Magnesia	Titania	Zirconia (stabilized)
Formula	Al_2O_3	BeO	G_2O_3	MgO	TiO_2	ZrO_2 (5% CaO)
Melting Point, C	2015	2530	2350	2800	1830	2600
Bulk Density, gm/cm³	3.79	2.86	7.40	3.58	4.7	5.35
Thermal Neutron Absorption Cross Section, cm^2/cm^3[a]	0.0101	0.0074	1090	0.0032	0.176	0.00571
Thermal Cond, cal/sec/cm²/C/cm	0.069 (100C) 0.021 (600C) 0.013 (1200C)	0.500 (100C) 0.107 (600C) 0.039 (1200C)	0.005 (1000C)	0.082 (100C) 0.026 (600C) 0.014 (1200C)	0.015 (100C) 0.008 (600C) 0.0076 (1200C)	0.004 (100C) 0.004 (600C) 0.0049 (1200C)
Coeff of Exp per C	6×10^{-6} (20C) 7×10^{-6} (500C) 9×10^{-6} (1000C)	8×10^{-6} (20C) 8×10^{-6} (500C) 9×10^{-6} (1000C)	10.5×10^{-6} (25–1000C)	11×10^{-6} (20C) 13×10^{-6} (500C) 15×10^{-6} (1000C)	7.5×10^{-6} (100–500C)	7.2×10^{-6} (70–1000C)
Mod of Elast, psi	52×10^6 (20C) 50×10^6 (500C) 32×10^6 (1000C)	45×10^6 (20C) 28×10^6 (800C) 12×10^6 (1400C)	18×10^6 (20C)	12×10^6 (20C)	$12.7 - 15.5 \times 10^6$ (20C)	36×10^6 (20C)
Spec Ht, cal/gm/C	0.21 (20C) 0.25 (500C) 0.28 (1000C)	0.24 (20C) 0.50 (500C)	0.176 (400C) 0.196 (1000C)	0.23 (20C) 0.26 (500C) 0.28 (1000C)	0.168 (0C)	0.12 (20C) 0.16 (500C)
Preferred Methods of Fabrication[b]	I, II, III	I, II, III, IV	I, II, III	I, II, III	I, II, III	I, II, III
Possible Thermal Reactor Applications[c]	F-S	F-M-R-S	C-Sh	F-S	S	S

[a] The total area of nuclei per cm³ is called "macroscopic cross section," referring to bulk area, in contrast to "microscopic cross section," which has to do with individual atomic absorption.

[b] Fabrication Numbers:
I—Cast and sintered
II—Extruded and sintered
III—Cold pressed and sintered
IV—Hot pressed

[c] Application Code:
F—Fuel elements
M—Moderator
R—Reflector
C—Control devices
S—Structural parts
Sh—Neutron shield

[d] Source: "Refractories for Nuclear Energy," American Refractories Institute Technical Bulletin No. 94, Feb 1956.

PROPERTIES OF GRAPHITE AND SOME CERAMIC CARBIDES[a]

Properties	Graphite	Beryllium Carbide	Boron Carbide	Silicon Carbide	Tantalum Carbide	Titanium Carbide	Tungsten Carbide	Zirconium Cartide
Formula	C	Be_2C	B_4C	SiC	TaC	TiC	WC	ZrC
Melting Point, C	3700 ± 100	decomposes 2100	2450	decomposes 2200	3880 ± 150	3140	2777	3530 ±25
Bulk Density, g/cm³	1.55	2.44	2.51	3.2	14.48	4.93	15.70	6.7
Thermal Neutron Absorption Cross Section, cm²/cm³	0.000350	0.0010	82	0.00647	0.964	0.277	0.915	0.0072
Thermal Cond, cal/sec/cm²/C/cm	0.298 (100C) 0.154 (600C) 0.105 (1000C)	0.56 (20C)	0.065 (20C)	0.049 (600C) (recrystal-lized)	0.053 (20C)	0.041 (20C)	—	0.049 (20C)
Coeff of Exp, per C	2×10^{-6} (20C) longitudinal 3×10^{-6} (20C) transverse	10.8×10^{-6} (38–982C)	4.5×10^{-6} (25–200C)	4.7×10^{-6} (20–1500C)	8.2×10^{-6} (20–2380C)	7.42×10^{-6} (24–500C)	5.2×10^{-6} (20C) 7.3×10^{-6} (1930C)	6.73×10^{-6} (24–500C)
Mod of Elast, psi	1.0×10^{6} (20C)	45×10^{6} (20C) 6-8% porosity	65×10^{6} (20C)	—	—	51×10^{6} (20C) sintered with 5% Co	102.5×10^{6} (20C)	49×10^{6} (20C) hot
Spec Ht, cal/gm/C	0.3 (20C)	—	0.443 (25C)	0.143 (0C)	—	0.201 (25C)	—	—
Preferred Methods of Fabrication[a]	Extrusion, graphitization at 3000C, machined	IV	IV	I, II, III, IV	IV	IV	IV	IV
Possible Thermal Reactor Applications[b]	F-M-R-S	F-M-R-S	C-Sh	F-S	S	S	S	F-S

[a] Fabrication code:
I—Cast and sintered
II—Extruded and sintered
III—Cold pressed and sintered
IV—Hot pressed

[b] Application code:
F—Fuel elements
M—Moderator
R—Reflector
C—Control devices
S—Structural parts
Sh—Shield

[c] Source: "Refractories for Nuclear Energy," American Refractories Institute Technical Bulletin No. 94, Feb 1956.
Reactor Handbook, U. S. Atomic Energy Commission, May 1955.

PROPERTIES OF SOME LIQUID METALS[b]

Properties	Bismuth	Lead	Potassium	Sodium	Tin	Sodium (22%)—Potassium (78%) Alloy (NaK)	Lead (44.5%)–Bismuth (55.5%) Eutectic
Melting Point, C	271	327.4	63.7	97.8	231.9	−11	125
Boiling Point, C (760 mm Hg)	1477	1737	760	883	2270	784	1670
Density, gm/cm³	10.3 (300C) 9.2 (962C)	10.51 (400C) 9.81 (1000C)	0.819 (100C) 0.676 (700C)	0.928 (100C) 0.780 (700C)	6.83 (409C) 6.64 (704C)	0.847 (100C) 0.703 (700C)	10.46 (200C) 9.36 (1000C)
Thermal Neutron Cross Section, barns/atom[a]	0.032	0.17	7.0	0.50	0.65	1.7	0.16
Spec Ht, cal/gm/C	0.035 (400C) 0.042 (1000C)	0.039 (327C) 0.037 (500C)	0.196 (75C) 0.188 (800C)	0.33 (100C) 0.30 (800C)	0.058 (250C) 0.076 (1100C)	0.238 (0C) 0.213 (800C)	0.035 (144-358C)
Viscosity, cp	1.662 (304C) 0.996 (600C)	2.116 (441C) 1.185 (844C)	0.515 (69.6C) 0.136 (700C)	0.69 (103.7C) 0.18 (700C)	1.91 (240C) 1.05 (600C)	0.47 (103.7C) 0.15 (700C)	1.7 (332C) 1.17 (600C)
Thermal Cond, cal/sec/cm²/C/cm	0.041 (300C) 0.037 (700C)	0.039 (330C) 0.036 (700C)	0.107 (200C) 0.085 (600C)	0.21 (100C) 0.16 (500C)	0.08 (240C) 0.078 (498C)	0.058 (100C) 0.064 (400C)	0.022 (160C) 0.027 (320C)

[a] Microscopic cross section. To find macroscopic cross section multiply by density in gm/cm³.
[b] *Liquid Metals Handbook*, Office of Naval Research, 1952.
Reactor Handbook, U. S. Atomic Energy Commission, May 1955.

high temperature oxidation. A number of the silicides have good chemical stability along with resistance to oxidation and acid attack even at relatively high temperatures.

Ceramic coatings have been developed for service at 1000 C from materials having low absorption cross sections for neutrons. These show promise for oxidation protection of high temperature alloy parts. They are comprised of high barium frits containing small amounts of ceria or mixtures of chromic oxide and ceria. The computed neutron absorption cross sections (microscopic) are in the range of 0.15 to 0.50 barns.

Silicon carbide

High thermal conductivity, low neutron absorption cross section and good refractory properties make silicon carbide an attractive possibility for reactor service. Recently developed techniques for applying silicon carbide coatings to graphite for protection against high temperature oxidation in air is also an application of interest in nuclear technology.

Silicon carbide bodies have been prepared without binders with a reported density of 3.1 compared with a calculated density of 3.21. Silicon carbide shapes of potential value in reactor designs are also made using silicon nitride as a bond. Silicon carbide-silicon cermets prepared by impregnation of preformed carbon shapes or of silicon carbide body with silicon offer a material with a number of attractive properties for reactor service.

Cermets

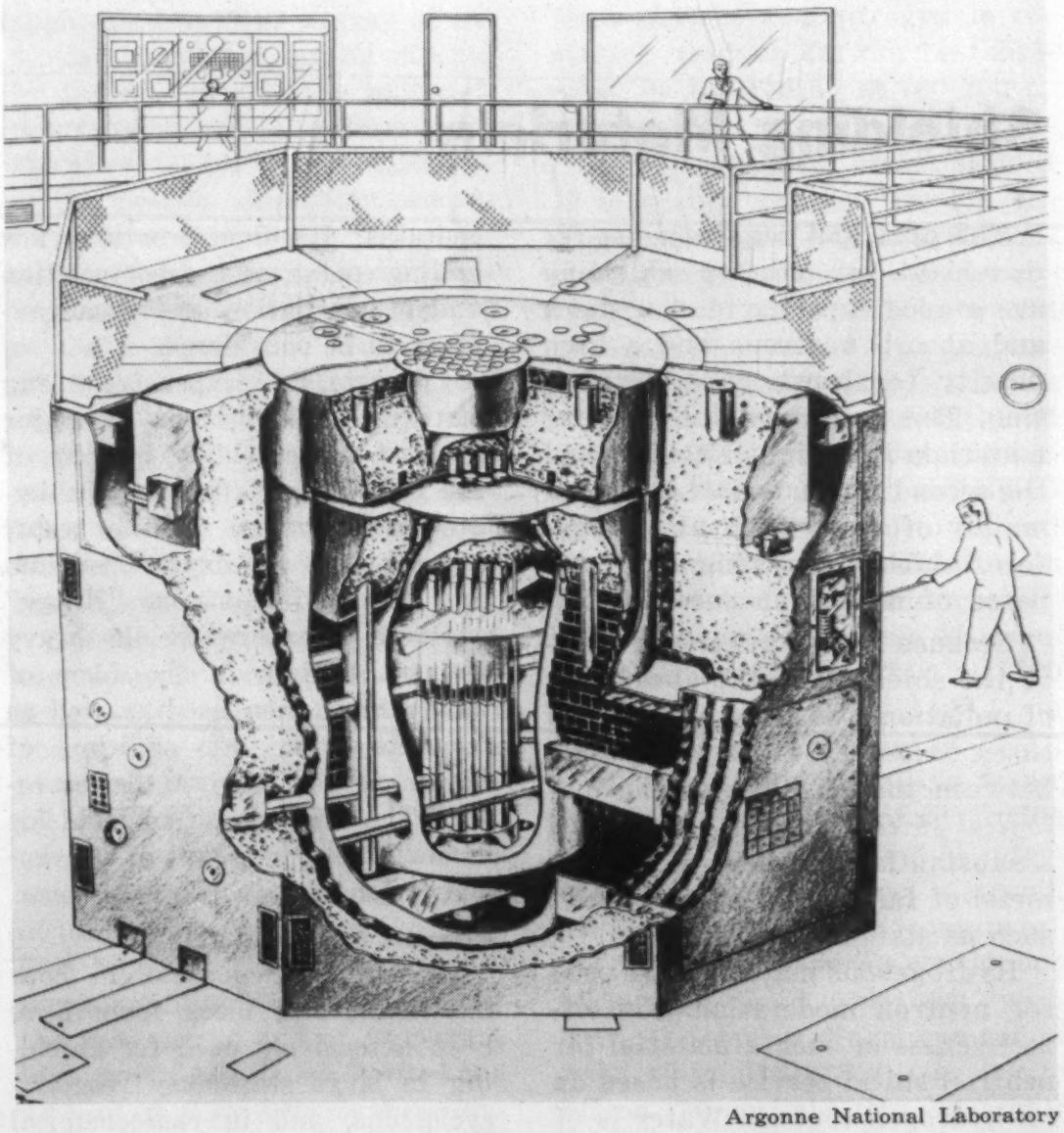
Cermets, ceramic-metal combinations, are being considered for use in fuel element fabrication and for structural components in nuclear reactors. Two cermets for potential service are chrome-alumina and silicon carbide-silicon. Consistently pore free bodies of moderate shrinkage can be fabricated from the compositions 72% Cr-28% alumina to give bodies having a density of 5.9. High temperature strength properties may be adequate for applications at 800 C and above. Oxidation of the material is negligible below 1000 C. The sustained load carrying ability shown by stress rupture behavior indicates that deterioration as a function of time is not excessive below 1000 C. Thermal shock resistance for this material is reported to be good.

Siliconized silicon carbide may be prepared by the impregnation of a porous graphite body with molten silicon. The neutron absorption cross section for this material is about 1 barn. SiC-Si has been prepared with a final density of 3.1; tensile strength at room temperature is about 10,000 psi.

Plastics and elastomers

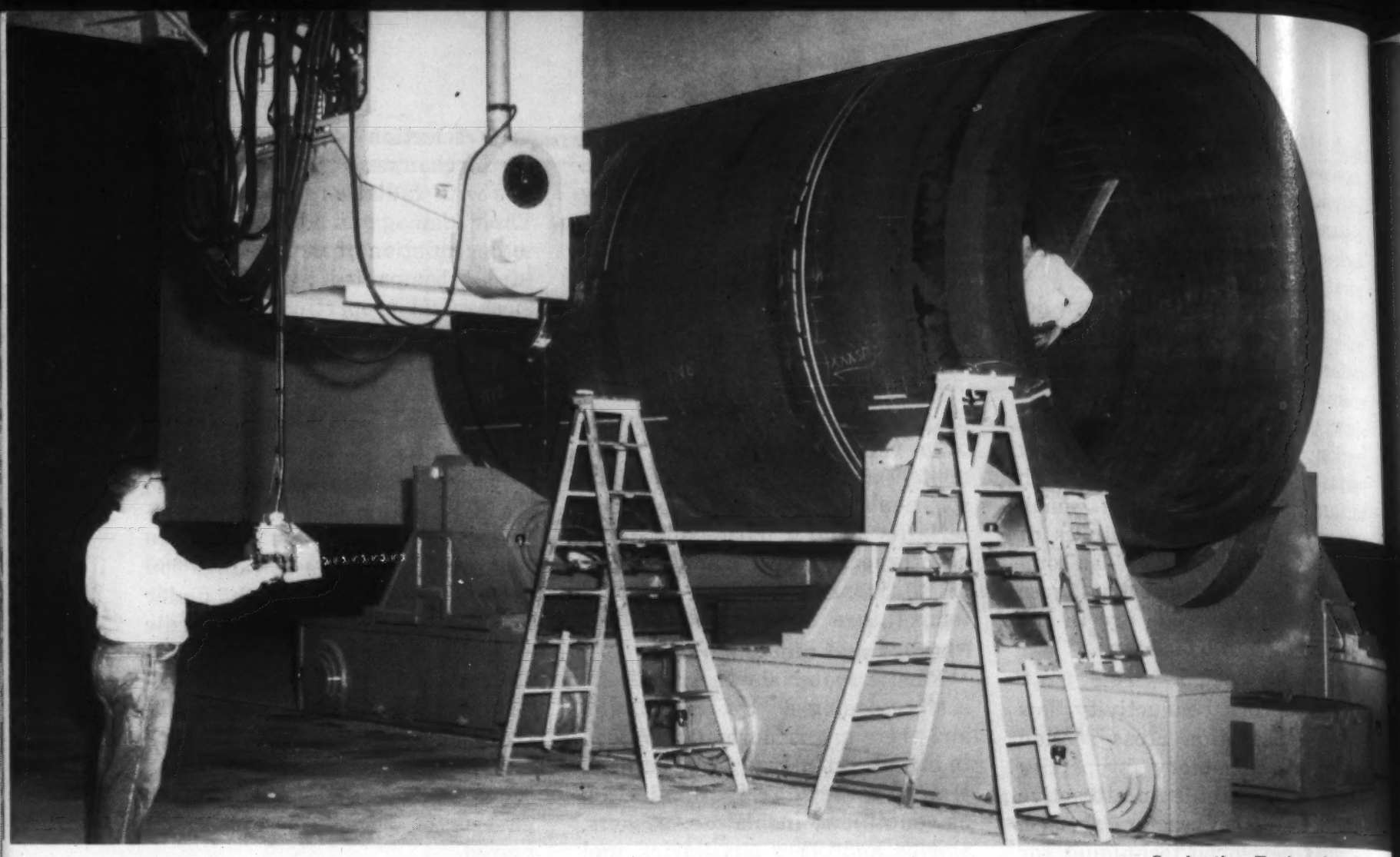
Plastic materials are relatively easily damaged by irradiation and their use is normally avoided in a high intensity radiation field. However, they do have application as containers, insulators, gaskets, shields and other auxiliaries, and their selection must be governed by the changes in physical properties with radiation to be expected. Their damage is apparently due to degradation of molecular structure accompanied by changes in mechanical properties. In general materials such as polyethylene, nylon and asbestos filled phenolics show less radiation damage than Teflon, Lucite and cellulose base plastics.

Natural rubber is more resistant to radiation damage than neoprene. Both materials are more sensitive to changes in elongation than in tensile strength under irradiation. Although the tensile strength of both of these materials increases with increased exposure after an initial decrease, the elongation changes of both materials becomes excessive and their engineering usefulness as gaskets or hose is seriously impaired.



Argonne National Laboratory

***Research reactors** are used to test the properties of materials for use in nuclear systems. Cutaway shows principal parts.*



Combustion Engineering, Inc.

***Wall of Shippingport reactor vessel** is inspected with a 15 million volt Betatron.*

Shielding Materials

The principal requirements for materials for reactor shielding are a good capacity to slow down and absorb neutrons and a high density to absorb gamma radiation. The first requisite calls for materials with light elements and the second for materials composed mainly of heavy elements. Therefore, shields are generally composed of more than one material.

Because heat is generated within the shield from the absorption of radiation, it is necessary in some cases, to interpose a *thermal shield* between the reactor and the *biological shield*. This may consist of a substantial thickness of a dense metal of fairly high melting point such as stainless steel.

Hydrogenous materials are used for neutron moderation. The effectiveness of such a material for neutron shield service is based on its hydrogen content. Water is of considerable interest because of the large amount of hydrogen it contains. Its liquid nature, low boiling point and decomposition under irradiation are disadvantages to be considered.

Concrete, an inexpensive strong structural material, is of major interest for shielding because of the moderating effect of the hydrogen contained in the water present, and the oxygen, calcium and silicate it contains. "Heavy" concrete incorporating the heavy element barium in the form of barite have been used as well as concrete with the addition of boron as the mineral "colemanite." The thickness of such shields is much less than that of conventional concrete.

Cement and concrete

Cement and concrete, in both monolithic and block form have been extensively used for shielding in large stationary reactors, cyclotrons, and in radiochemical laboratories. The cost considerations in concrete shield designs involve: 1) cost of materials, 2) quantity required, 3) method of fabricating, and 4) dimension tolerances for holes and cutouts. Material costs are generally higher than for conventional concrete because of the more costly heavy aggregate used and the use of cement other than Portland.

The comparative cost of concrete shielding can be crudely estimated on the basis of density since gamma shielding power is roughly proportional to density of the shield. A more critical appraisal would give consideration to the measured shielding properties in terms of the source shielded, complexity of the shield design, and space and weight requirements.

Concrete compositions generally may be readily adjusted to meet nuclear requirements by adding materials of high neutron capture cross section as aggregates or as components in the cement-

ing phase. Magnesium oxychloride cement because of its higher water content compared to Portland cement can be employed to increase the hydrogen content of the shield.

The mechanical properties of heavy concretes prepared with Portland cement are of the same order as those of conventional Portland cement. Although magnesium oxychloride cements have a higher strength than Portland cement their stability is questionable.

Metals

Iron is the only heavy element so far used in massive form for shielding. However, iron filings and punchings and iron oxides are employed in special concretes for shielding service. Lead is considered for reactor shielding applications because of its high density and fabricability but its softness and low melting point are major drawbacks. Bismuth suffers from the same disadvantages as lead. Tantalum and tungsten are of potential interest, but their high cost would restrict their application. The carbides, nitrides and borides, which generally have high melting points, are also being considered.

Boron

The boron isotope B^{10} is an effective absorber for thermal neutrons and there are a number of water soluble boron compounds that may be added to a water shield to increase its effectiveness. "Boral," a mixture of boron and aluminum, heated and rolled into sheets that are subsequently clad in aluminum, is a promising shielding material because of its satisfactory mechanical properties and because it absorbs neutrons without producing high energy gamma. "Boraxal," made from boric oxide and aluminum, is another interesting material similar to Boral. It is less expensive but has fewer boron atoms per unit volume.

Control Materials

Thermal reactors are generally controlled by changing the amount of neutron absorbers present. The absorber controls are referred to as "control rods" and are usually in solid form. These should have high absorption characteristics for thermal neutrons, adequate strength, low mass to permit rapid movement, good resistance to corrosion, stability under heat and irradiation, and satisfactory heat transfer.

Rods or strips of boron steel or cadmium have been extensively used for this application in existing reactors. The rare earth oxides and compounds of boron and hafnium are among the ceramics suggested for reactor control devices because of their relatively high neutron absorption characteristics. The boron carbides can be fabricated into various shapes. Elemental boron as well as the rare earth oxides may be used in small additions to provide a suitable ceramics body.

Boron nitride, which can be made in bulk form, possesses good oxidation resistance up to 1300 C and is resistant to thermal shock. Although little is known about the stable refractory borides, certain compounds such as hafnium boride, tungsten boride and zirconium boride may have application and are worthy of attention. Control might be effected by the use of a fertile material, natural uranium or thorium as an absorber, which would make use of the neutron absorption process to produce more fuel.

In a fast reactor, absorber controls are unsatisfactory because of the generally low neutron absorption characteristics of the elements for high energy neutrons. In such reactors, control may be effected by removing fuel from the core or by movement of the reflector.

Rare earth metals

Because they include some of the elements having the highest cross section for thermal neutron absorption, the rare earths are of potential value for reactor control devices. Gadolinium, for example, has the highest thermal neutron absorption cross section of all of the elements in the periodic table, 44,000 barns. The expense and difficulty of separating the rare earths and of preparing high purity metals has limited the amount of work done on these materials. The conventional forming and fabrication techniques have been successfully used on some of the rare earth metals. Protection from oxygen and nitrogen is essential. Gadolinium can be fabricated by hot rolling at 700-900 C.

Ceramics

Requirements for ceramics used in absorber control service include high density to insure maximum concentration of the absorbing element per unit volume and adequate mechanical properties.

Samarium oxide (Sm_2O_3) forms a ceramic of medium strength and density when fired in dry pressed form at 1300 C. Fired at 1500 C the density is increased to 7.4 and the ceramic loses its stability to boiling water. Gadolinium oxide (Gd_2O_3) forms a ceramic of somewhat higher density (7.0) at 1300 C than does Sm_2O_3. At 1500 C its density is slightly higher (7.6), but its stability in boiling water is unchanged. Hafnium oxide (HfO_2) is also of potential interest as a reactor control material. It closely resembles zirconium oxide (ZrO_2). HfO_2 forms continuous series of solid solutions with ZrO_2. It forms a single compound with silica, HfO_2, SiO_2, similar to zircon. Monoclinic HfO_2 is stable to 1700 C; the tetragonal form is found above this temperature.

Moderator and Reflector Materials

The function of the moderator in a thermal reactor is to reduce neutrons of fission energy to thermal energy at a minimum of loss and in the smallest space. This requires a low atomic weight. Moderator materials must have a high scattering cross section, a large energy loss per collision and a low absorption cross section for thermal neutrons.

The purpose of the reflector is to scatter or reflect as many leakage neutrons as possible back into the pile and the reflector materials must meet the same requirements as the moderator, i.e., high scattering cross section and low neutron absorption characteristics.

The only materials that are useful as moderators and reflectors are: ordinary water, heavy water (D_2O), beryllium (metal oxide or carbide), graphite, and possibly certain of the metal hydrides.

Water

Water is an important material in reactor technology because of its possible application as both moderator and coolant in power reactors. Ordinary water as a moderator has the advantages of low cost, good slowing down power and small migration length for thermal neutrons. Its neutron absorption cross section is relatively high, which confines its use to reactors containing enriched fuel elements.

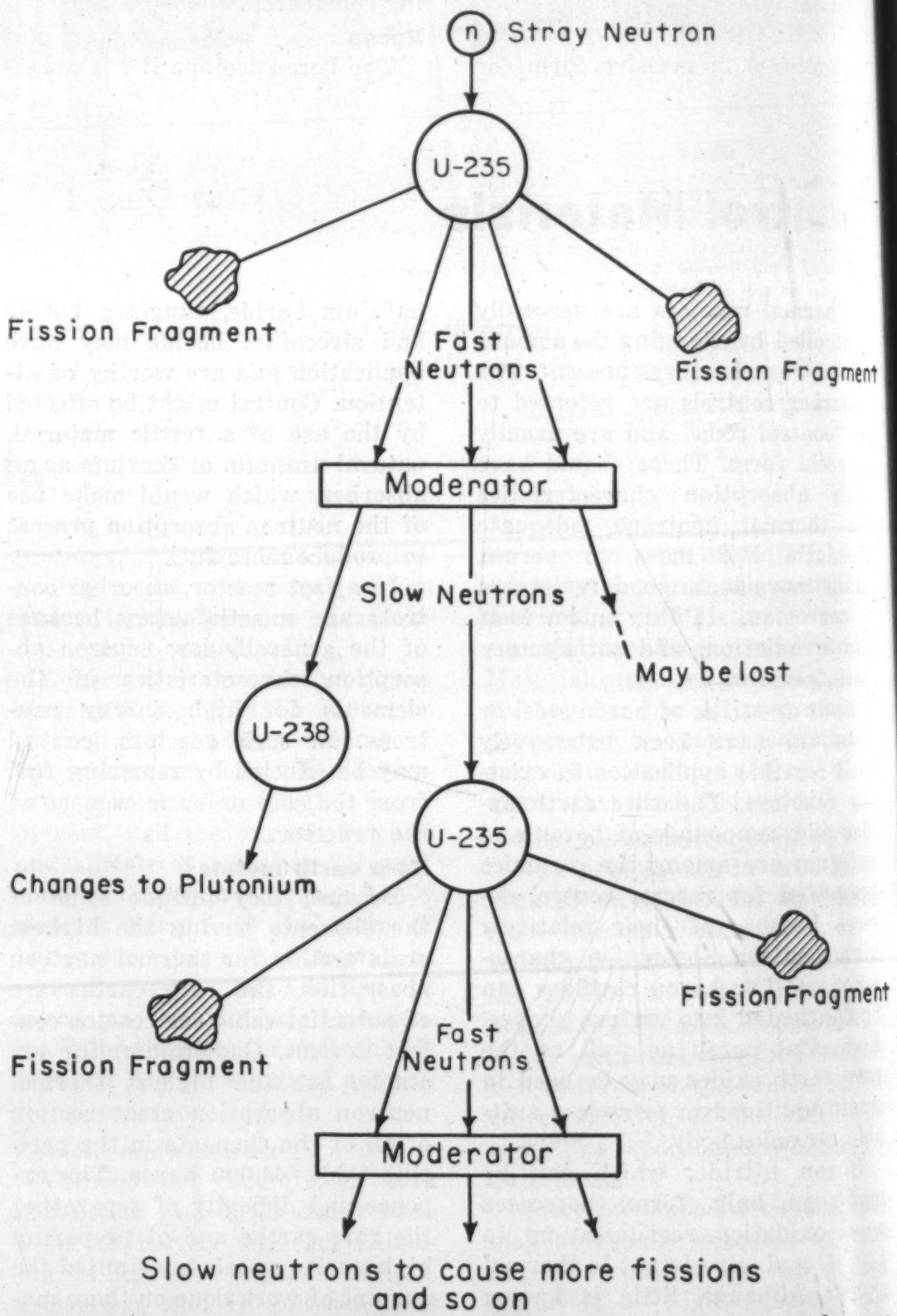
In power operation, temperatures above the atmospheric boiling point are required. This gives rise to fabrication, construction and corrosion problems. For example the PWR (Pressure Water Reactor), first commercial power producer, is designed to operate at pressures around 2000 psi and temperatures of 260-315 C. Water becomes radioactive when subjected to irradiation, emitting short life gammas. Many impurities present also become radioactive so that a completely leakproof system is required. Water is decomposed by nuclear radiations into hydrogen and oxygen and the gas so liberated must be recombined to prevent hazardous explosions. A high degree of purity is required to reduce corrosion and scale formation.

Heavy water

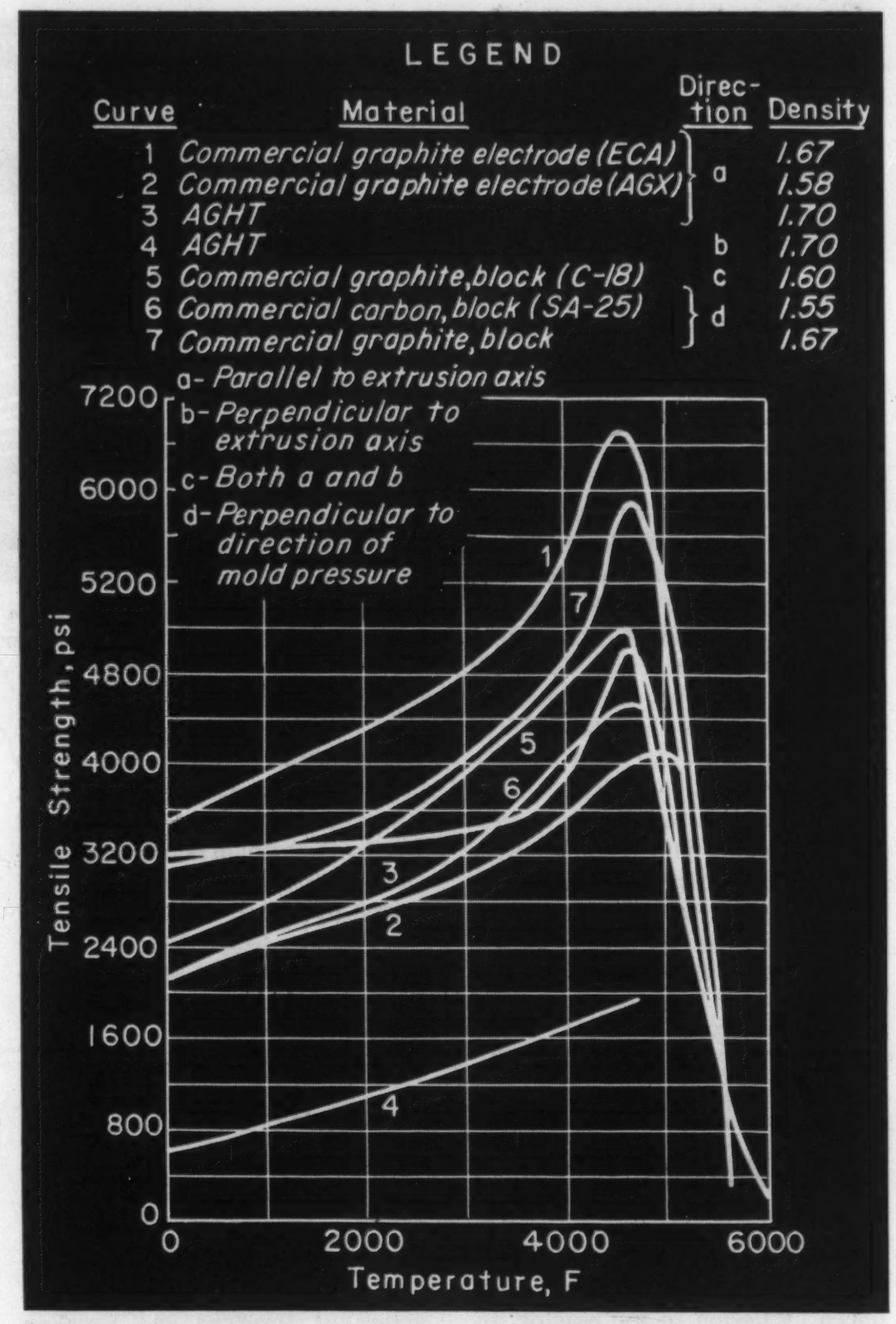
Heavy water, because of its exceptional moderating ratio and good slowing down power, is an excellent moderator. It permits reactors to be designed using natural uranium fuel elements. The high cost of heavy water requires that the system be leakproof and be kept as small as possible. As in the case of ordinary water, provision must be made for recombining decomposed gases. The high cost of heavy water has restricted its more widespread application.

Beryllium

Beryllium has nuclear properties that make it particularly attractive. It has excellent stability under irradiation. Under an exposure of 5×10^{18} n per sq cm at 30 C, no significant changes occur in length, density, hardness, modulus, electrical resistivity or thermal conductivity.



***How moderator slows neutrons** in a fission chain reaction to speeds more likely to produce fission.* (Babcock & Wilcox Co.)



Effect of temperature *on the tensile strength of various graphites. Reprinted from M. C. Cody and F. W. Boulger, "The Properties of Graphite," Battelle Memorial Institute, June 20, 1950.*

Beryllium ceramics

Beryllium oxide (BeO) is of particular interest because of its high service temperature, good thermal conductivity and low neutron absorption characteristics. It also has good resistance to thermal shock. Beryllium oxide, however, is attacked at high temperatures by water vapor.

High density beryllium oxide must be prepared by hot pressing or by sintering at very high temperatures. Beryllium carbide (Be_2C) is refractory and has low neutron absorption characteristics but it is difficult to produce and fabricate. Because of their possible toxic properties, considerable safety precautions are necessary for the safe handling of beryllium compounds.

Under irradiation of 10^{19} n per sq cm, BeO shows serious decreases in thermal conductivity and compressive strength at room temperatures and dimensional changes of the order of 1% are produced.

Graphite

Graphite has been employed more extensively than any other material for moderator service in existing reactors. Although its nuclear properties are not quite as good as heavy water, it has a high order of availability at reasonable cost. Its stability in oxygen and water-vapor-free atmosphere at elevated temperatures, good heat transfer characteristics, generally satisfactory mechanical properties and machinability add to its attractiveness as a reactor material. Its susceptibility to oxidation, relatively low impact strength and porous character are disadvantages.

Graphite does not melt on heating at atmospheric pressure but sublimes at 3650 C. Because of preferred orientation of its individual crystallites, graphite exhibits anisotropic characteristics that are reflected in its thermal, electrical and mechanical behavior and values for these properties vary widely with direction. The tensile strength of graphite increases with temperature reaching a maximum around 2500 C at which point the value is roughly double the room temperature figure. Creep rate is small below 1500 C, but may become large at elevated temperatures. Its resistance to thermal shock is particularly good.

Artificial graphite so far produced for reactor service has a density of about 1.6 to 1.7 gm per cu cm compared with a theoretical value of 2.25. More recent developments have led to the commercial production of graphite having higher densities that offer more useful material for reactor service since the moderating properties of graphite are roughly proportionate to its density.

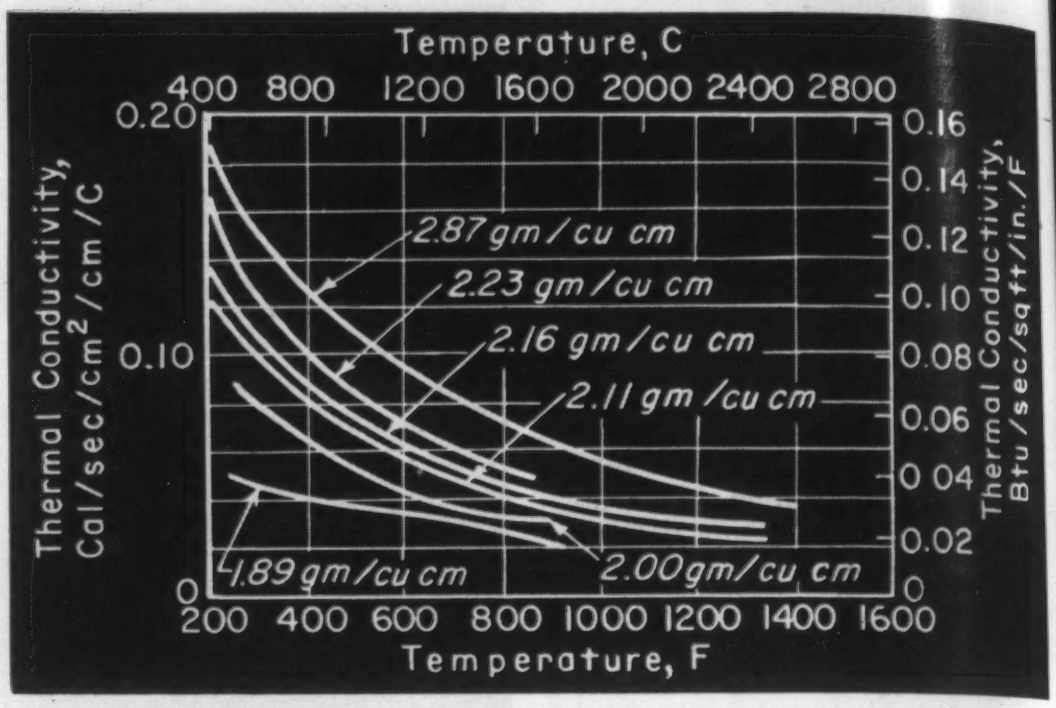
Radiation effects

Graphite is susceptible to radiation damage. Neutron irradiated graphite becomes harder, stronger, more brittle, more difficult to machine, and exhibits decreased

thermal conductivity. Conductivity may be reduced by a factor of 50 or more. Electrical resistivity arises quickly at around 2×10^{20} n per sq cm, decreases slightly, then begins a slow increase again.

The principal radiation damage effects are distortion of the lattice and trend toward amorphous form. Damage in irradiated graphite, however, can essentially be removed by suitable annealing treatments or practically prevented by maintaining temperature above 500 C during irradiation procedures.

Graphite is used as a moderator in power reactors under construction or being planned. Russia's 100 MW atomic power station will use 500 tons of graphite in two thermal reactors as will Britain's two thermal reactors producing more than 92 MW of electricity at Calder Hall and the Dounreay, Scotland, fast breeder reactor that is scheduled to produce about 60 MW of heat. Graphite in the form of prism of hexagonal cross section canned in 0.035-in. zirconium sheets is the moderator in the Sodium Reactor Experiment (North American Aviation Co. Project) at Santa Susana, Calif., that is designed to produce 20 MW of heat (7.5 MW of electricity).



***Thermal conductivities** of beryllia bodies of different densities. Reprinted from M. C. Cody and F. W. Boulger, "The Properties of Beryllium Oxide," Battelle Memorial Institute, Dec 15, 1949.*

Metal hydrides

Metal hydrides are a useful source of hydrogen of high purity that has excellent moderator characteristics. Although they are generally unstable at elevated temperatures, there is a possibility that by suitable canning techniques, large amounts of hydrogen may be contained in combination with the metal.

Coolants

The function of reactor coolants is to remove the heat produced by fission in the reactor. In power reactor systems the heat from the coolant is converted to useful work in a conventional steam boiler or in turbine units. The reactor coolant may be a gas or liquid. The general criteria for coolants include good heat transfer characteristics, low pumping power requirements, high boiling point, and low melting point, stability under irradiation, high temperature, good corrosion properties, low neutron capture characteristics, ability to be handled safely and reasonable cost.

Water

Ordinary water, when sufficiently pure, is an obvious choice as a liquid coolant and is used for this purpose in the production reactors at Hanford and Savanna River. It has the advantage of being usable both as moderator and coolant. Its principal drawbacks are fairly high neutron absorption cross section, decomposition under irradiation, corrosive action on most metals and a low boiling point.

The use of boiling water as a coolant is attractive from the heat transfer standpoint, and reactors have been designed to use boiling water as a moderator coolant, e.g., the "Borax Reactor" at Arco, Idaho. Such a reactor will produce steam without the use of a heat exchanger.

Heavy water, because of its much smaller capture cross section for thermal neutrons would provide greater neutron economy in a reactor system than ordinary water. However, its high cost militates against such use at present.

Liquid metals

Certain liquid metals offer attractive possibilities as heat transfer media in high power reactors. Their heat transfer properties are excellent and they have good thermal and radiation stability. Their disadvantages are difficulty in handling and their corrosive properties. One of the problems encountered with liquid metal coolants is that of "mass transfer," a phenomenon consisting of

the dissolution of the structural metal in the hot zone of the equipment and its subsequent deposition in the cold zone. This property is dependent upon the temperature coefficient of the solubility of the structural metal in the liquid metal.

Liquid sodium and an alloy of 22% Na and 78% K (referred to as "Nack") have received considerable attention as heat transfer media for reactors operating at elevated temperatures. Although NaK alloy has less favorable heat transfer properties than sodium alone, it is a liquid at ordinary temperatures, an advantage that led to its choice as coolant in the Experimental Breeder Reactor (EBR). Molten sodium is a potential hazard in contact with water but knowledge of its safe handling has led to its planned use in the Sodium Reactor Experiment (SRE), a project of the North American Aviation Co.

Mercury has been used as a coolant in the Los Alamos Fast Reactor, but its high neutron capture cross section precludes its use as a heat transfer medium in thermal reactors.

Bismuth and lead have acceptable cross sections for thermal neutron capture, but their individual melting points are relatively high. A bismuth-lead alloy containing 2.5% magnesium with a melting point of 250 C might also be of interest. A major disadvantage of bismuth is that it forms hazardous radioisotopes as the result of nuclear reactions. Chromium steels (2½% Cr- 1% Mo and 5% Cr-1½% Si) show promise as container materials for handling molten bismuth and probably for lead and its alloys.

Fused salts and hydroxides have been considered as reactor coolants. Of interest are mixtures of lithium (Li_7), sodium and potassium fluorides and beryllium fluoride (BeF_2). They are attractive because of their possible use as both moderators and coolants.

Organic liquids, because of the presence of carbon and hydrogen elements of low neutron capture cross section, have been studied as moderator-coolants but their main drawback is their probable instability under irradiation.

Gases

Gases can also be used as heat transfer media because of their generally good radiation and thermal stability, and ease of handling. The use of gas in a reactor system offers the possibility of eliminating corrosion resistance and operational hazards and permits higher reactor operating temperature if suitable construction materials are found. The principal disadvantage of gas as a working medium is its relatively poorer heat transfer characteristics when compared with the liquids under consideration for heat exchange purposes.

Air has been used as a coolant in production reactors operating at low temperatures where no attempt has been made to utilize the heat available. Its heat transfer properties are relatively poor and the power requirements for pumping it are high.

On the basis of heat transfer and pumping power, hydrogen is the most efficient of the gaseous coolants. However, its susceptibility to violent explosion if mixed with air and the problem of developing container materials resistant to attack or embrittlement by hydrogen militate against its use.

Helium is attractive because of its relatively good heat transfer properties, low neutron capture cross section and lack of handling hazards. It is thermally stable and not affected by radiation and presents no corrosion problems when in contact with structural materials.

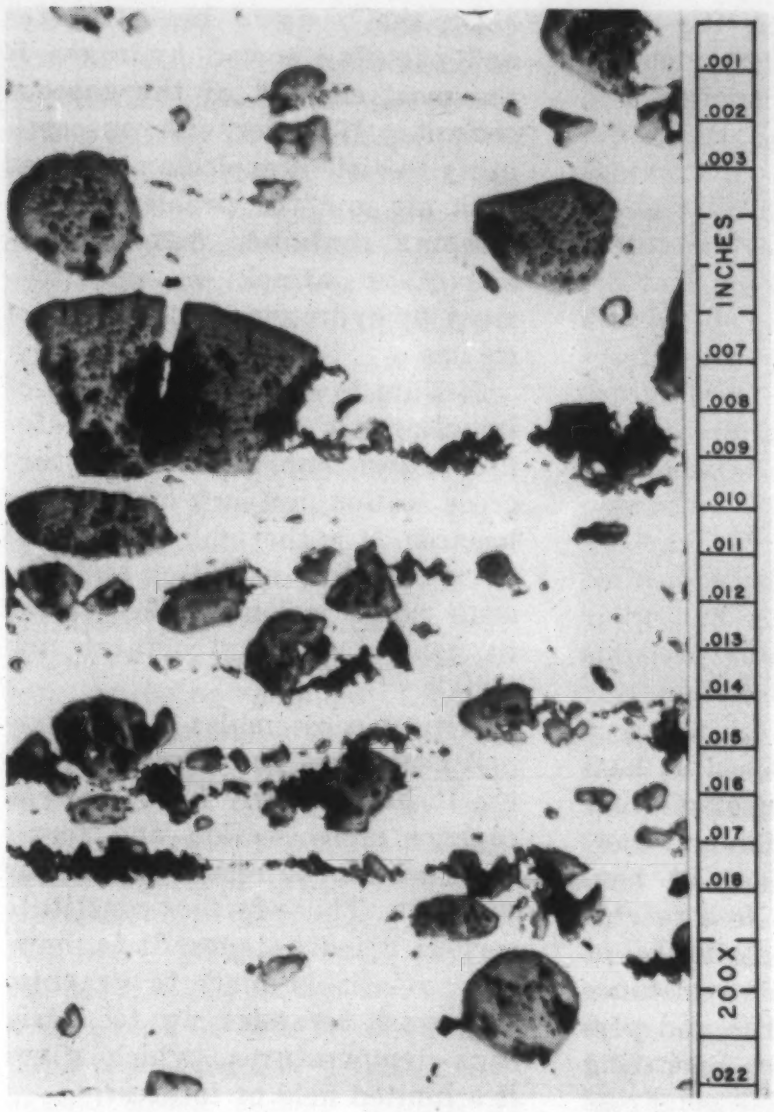
Nitrogen resembles air in thermal properties and pumping power. It has a fairly high neutron capture cross section and forms carbon-14 as a result of nuclear reactions. These factors constitute serious disadvantages. It is, however, relatively inert to graphite and most ceramics up to fairly high temperatures, which gives it a limited field of interest.

Carbon dioxide has much to recommend it as a heat transfer medium, particularly from the standpoint of safety. It does not readily attack metals although it does react with graphite at elevated temperatures. Its ready availability tends to offset its less efficient comparison with helium with regard to heat transfer, pumping power and nuclear properties. It has been selected as the heat transfer medium for the British Power Reactor under construction at Calder Hall, Cumberland.

Nuclear Fuels and Fertile Materials

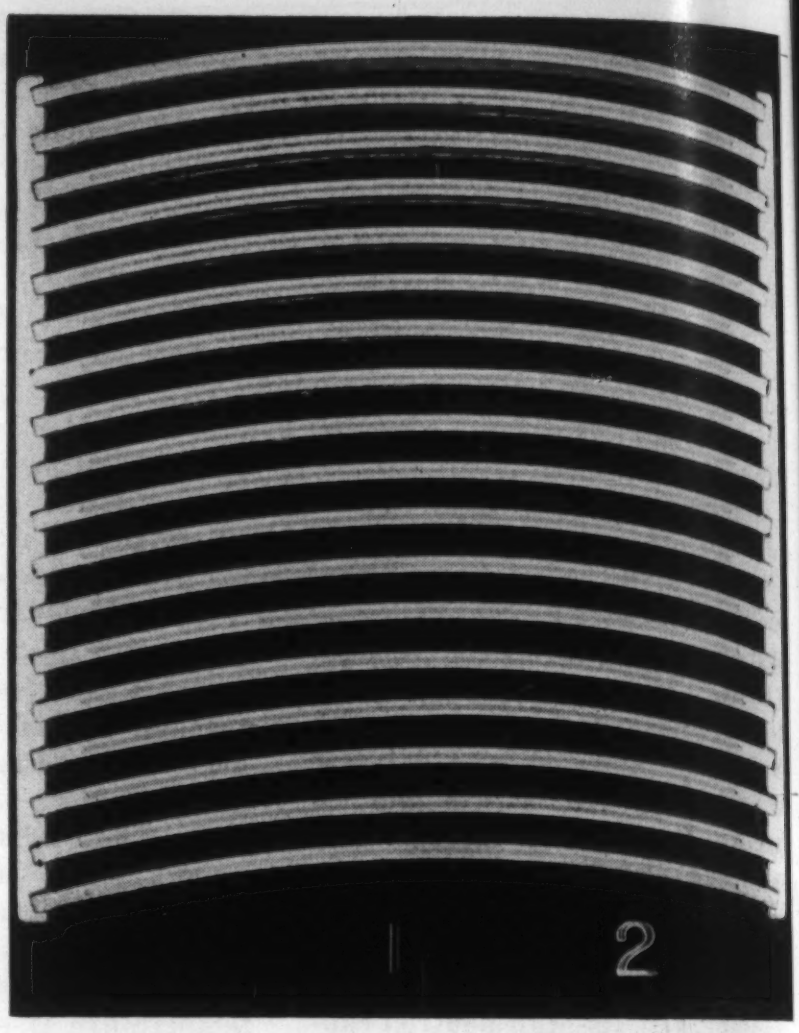
The major effort in the investigation of materials for nuclear power production has been on fuel elements, the most important of the reactor components. Fuel elements may consist of fissionable materials dispersed in a selected diluent and encased in a structure that has a high degree of fission product retention or they may be composed of solid shapes of fissionable material suitably clad.

Solid fuel elements for heterogeneous reactors must have adequate strength at operating temperatures, good stability to radiation damage, resistance to corrosion by the surrounding media, possess good heat transfer characteristics, and be amenable to fabrication at reasonable cost and be capable of being handled and chemically processed.



Oak Ridge National Laboratory

Micrograph of typical fuel plate *shows urania dispersed in aluminum.*



Oak Ridge National Laboratory

Cross section *of Geneva Reactor fuel assembly. Core material, Al-UO_2, was made by powder metallurgy techniques.*

Fluid fuels are used in the form of a solution or slurry in homogeneous reactors. The liquid medium may be ordinary water, heavy water or liquid metals or molten salts. The advantages of fluid fuels over solid fuels are the absence of complex fabrication problems, lack of thermal stresses, and absence of heat transfer and radiation damage problems. The use of circulating liquid fuel systems makes possible the continuous chemical processing of the fuel. The principal disadvantages are finding suitable fuel-carrying liquids having low melting points and having low vapor pressures at elevated temperatures. Corrosion of equipment is also an important disadvantage of liquid fuels and in the case of slurries the danger of settling is a special problem.

The primary fuel for nuclear reactors is uranium in the form of natural uranium, which contains less than 1% of the fissionable isotope U^{235} or enriched uranium in which the fraction of U^{235} present in natural uranium has been increased. Secondary fuels include plutonium, which is derived from natural uranium, and the fissionable isotope U^{233}, which is produced by neutron absorption in thorium.

The type and size of the reactor system governs the choice of fuel. Enriched U^{235} is preferred for small reactors with low power levels in view of the relatively small cost of the fuel compared to other charges. The possibility of high excess reactivity with relatively low fuel inventory makes the use of U^{235} fueling of research reactors attractive. Advantage will be taken of the possibility of converting or "breeding" in the choice of fuel element systems for power reactors because of the obvious advantage of the reduction in fuel costs. Plutonium and U^{238} are preferred for fast reactor service because of their high conversion ratio.

Fuel element design

The principal objective of fuel element design is to produce maximum life and high specific power (watts per gram U^{235}). The minimum life for fuel should be 2% burnup. This is about the life that is possible because of the poisoning in thermal reactors. High temperature, heat flow, corrosion and interdiffusion of fuel and clad are all factors seriously influencing fuel element life.

Massive uranium metal slugs have been most generally used as the fuel in existing reactors. However, more recent designs consider uranium alloys or dispersions of uranium in metals or ceramics.

Ceramic materials offer a possible solution to fuel element problems in reactors designed to operate at elevated temperatures. They are particularly suited for

use in gas cooled reactors operating above 1000 C. Some ceramics are under consideration for fuel element service in liquid cooled reactors because of their resistance to corrosion in certain environments. The principal disadvantage has been their generally poor resistance to thermal fracture and relatively poor heat transfer properties.

A ceramic compound of uranium has received considerable attention because of its refractoriness, dimensional stability in an oxygen free atmosphere and resistance to aqueous corrosion compared to uranium metal. It is of interest in proposed fuel system involving dispersions of uranium in ceramics. Typical of such systems are UO_2 in BeO; UO_2 in graphite; UO_2 in SiC; and UO_2 in ThO_2.

Thorium oxide (ThO_2) is of potential interest as a breeder material in a high temperature reactor because of its refractoriness and stability at elevated temperature. Cermets also offer possibilities for combining high service temperatures with good heat transfer characteristics. Two materials of interest in this class are Cr-Al_2O_3 and SiC-Si combinations containing uranium.

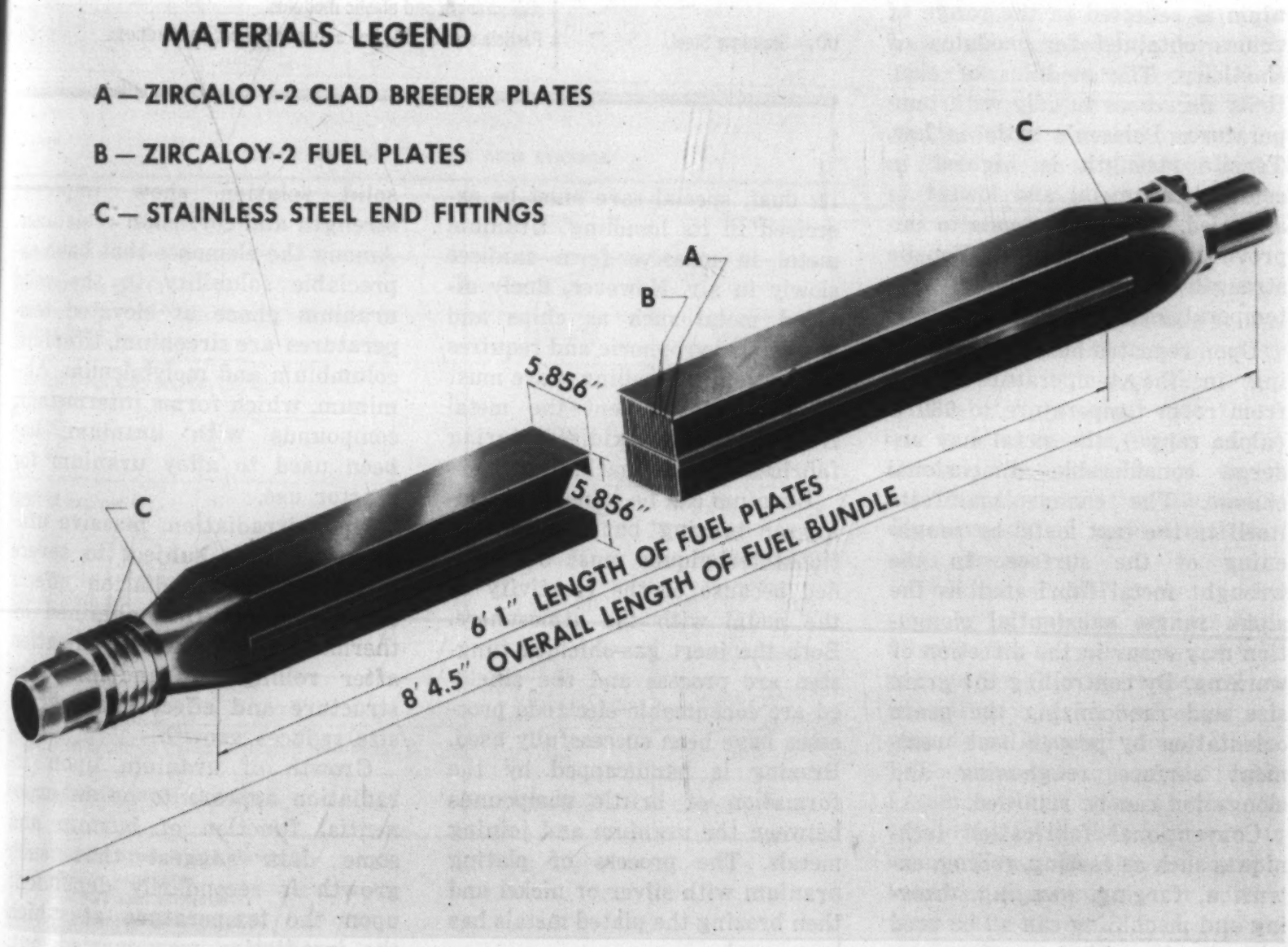
Aqueous slurries show promise for fuels or breeder blanket applications. Thorium oxide appears to be a promising thorium compound for breeder service because of its resistance to corrosion and its stability in aqueous solution.

Plutonium can be used for fast power breeder reactors because of its high average yield of 3 neutrons per Pu^{239} fission. Its principal role to date has been as a product of nuclear reactors. In one instance, in the Los Alamos Fast Breeder Reactor, it has served as a reactor fuel.

Uranium

Uranium is the only naturally occurring reactor fuel. Massive metallic uranium clad in aluminum or stainless steel has been used for fuel elements in most existing reactors. However, because of its poor corrosion resistance and distortion under irradiation, most of the new heterogeneous power reactor designs call for uranium alloy or dispersion type fuel elements. In the latter case, fine particles of the metal or oxide are dispersed in a metal or ceramic matrix.

Uranium metal exhibits three crystalline forms, the alpha phase, (orthorhombic) which is stable up to 660 C, the beta phase (tetragonal) which exists between 660 and 760 C, and the gamma phase (body centered cubic) which exists from 760 C to the melting point. This characteristic



Babcock & Wilcox Co.

Fuel element design *proposed for the Consolidated Edison Co. Reactor. Assembly employs a sandwich type structure of source and fertile materials.*

has a great significance in the treatment and behavior of the material at elevated temperatures.

Uranium's mechanical properties are markedly affected by anisotropy or preferred orientation of the internal structure, which is a function of fabricating history and heat treatment. Minor amounts of carbon present also have a pronounced effect on mechanical properties.

The hardness of cast annealed metal can be increased from an average value of Rockwell B 90 to 115 or more by cold working. When heated to 150 C the hardness of uranium decreases and complete annealing occurs at 600 C to 700 C. The hardness of the beta phase increases to a Brinell number of 30 or 40. The hardness decreases with a further increase in temperature and the gamma phase (above 772 C) is too soft to measure on the Brinell scale.

The anisotropic nature of uranium is reflected in the range of values obtained for modulus of elasticity. The modulus of elasticity decreases rapidly with temperature. Poisson's ratio is low. Tensile strength is highest in cold-worked metal and lowest in annealed. Quenching tends to improve the tensile strength. Tensile strength decreases rapidly with temperature increase.

Upon repeated heating and cooling in the temperature range from room temperature to 660 C (alpha range), the metal may undergo considerable dimensional change. The change manifests itself in the cast metal by roughening of the surface. In the wrought metal fabricated in the alpha range, substantial elongation may occur in the direction of working. By controlling the grain size and randomizing the grain orientation by proper heat treatment surface roughening and elongation can be retarded.

Conventional fabrication techniques such as casting, rolling, extrusion, forging, swaging, drawing and machining can all be used with uranium. Since uranium presents a health hazard from whole body radiation and inhalation of its dust, special care must be exercised in its handling. Uranium metal in massive form oxidizes slowly in air. However, finely divided metal such as chips and powder is pyrophoric and requires precaution in handling. Care must be taken to prevent the metal from becoming oxidized during fabrication and machining.

Uranium can be joined by welding or brazing but the conventional techniques must be modified because of the reactivity of the metal with the atmosphere. Both the inert gas-shielded tungsten arc process and the shielded arc consumable electrode processes have been successfully used. Brazing is handicapped by the formation of brittle compounds between the uranium and joining metals. The process of plating uranium with silver or nickel and then brazing the plated metals has been used.

Alloys of uranium containing small amounts of added metal in solid solution show improved strength and corrosion resistance. Among the elements that have appreciable solubility in the solid uranium phase at elevated temperatures are zirconium, titanium, columbium and molybdenum. Aluminum, which forms intermetallic compounds with uranium, has been used to alloy uranium for reactor use.

Upon irradiation, massive uranium metal is subject to severe distortion. The radiation effects are similar to that obtained by thermal cycling. Recrystallization after rolling to randomize the structure and effect small grain size reduces growth.

Growth of uranium upon irradiation appears to be an exponential function of burnup and some data suggest that such growth is secondarily dependent upon the temperature at which the irradiation was carried out. Surface distortion of uranium on irradiation as in thermal cycling

CHANGES IN ENGINEERING PROPERTIES OF URANIUM ITS ALLOYS AND COMPOUNDS UPON IRRADIATION

Material	Radiation Effects
Uranium (single crystals)	Irradiating single crystals of uranium at 200 C to 0.03% burnup caused 15% growth in the 010 direction; irradiation at 500 C caused no growth.
Uranium-Aluminum Alloys	Aluminum with 5-17% uranium showed 1% dimension change with exposures to 0.6% burnup. Thermal conductivity shows a linear decrease to about ⅔ of initial value. At 0.05% burnup, the density decreases about 3%.
Uranium-Chromium Alloys	The presence of 0.1-0.2% chromium in uranium markedly improved stability. The addition of molybdenum, columbium or zirconium is also effective but large quantities are required.
Uranium-Zirconium Alloys	Alloys of zirconium and uranium have good dimensional stability at 0.1% burnup with density decrease of about 1% and loss in thermal conductivity of around 5%.
Uranium-Molybdenum Alloys	Alloys of 0.61% molybdenum in uranium averaged 13% length increase after 5 x 10^{19} nvt exposure when preannealed below 500 C, specimens preannealed at 500 C showed only 2% length increase. Alloys containing 9% molybdenum showed no growth at 2.5 x 10^{19} nvt.
Uranium-Graphite	Radiation damage severe in such systems because of anisotropic nature of graphite.
Uranium-Beryllium Alloys	At 0.06% burnup beryllium alloys containing 0.5-3% uranium showed only minor dimensional and density changes.
Uranium-Thorium Alloys	Thorium alloys containing 1-5% uranium show only minor dimensional and density changes.
UO_2—BeO	After 0.0005% burnup, samples containing 2 and 10% UO_2 show 1% increase in linear dimensions and a loss of 30% in compressive strength and elastic modulus.
UO_2—Stainless Steel	Particle size of UO_2 has a marked effect on hardness.

takes the form of a peculiar "orange peel" surface roughening effect. The corrosion resistance of uranium metal is markedly decreased for U_3Si and for uranium alloys containing 5% Zr, 1.5% Nb and 9% Mo.

Uranium ceramics

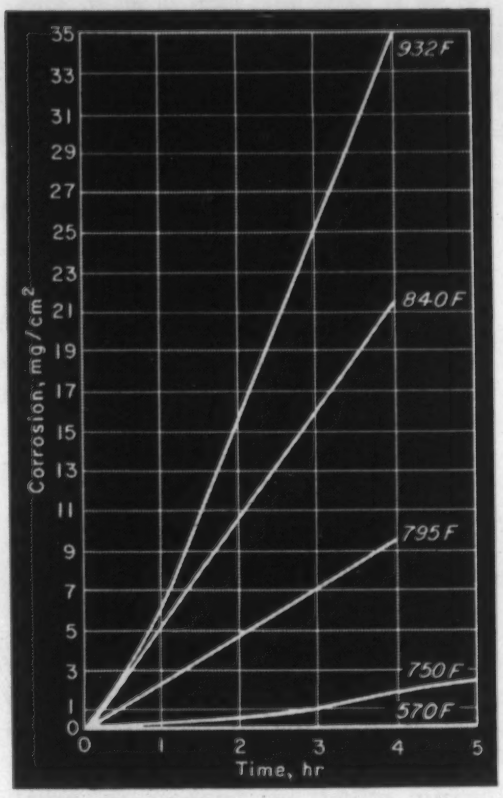
UO_2 looks promising for high temperature reactor service because of its high temperature stability. It is also of considerable interest in low temperature designs because of its dimensional stability in an oxygen free atmosphere and its resistance to aqueous corrosion compared to metal.

UO_2 oxidizes in air and must be fabricated in an oxygen free atmosphere. It may be used in fine particles dispersed in a matrix of stainless steel, zirconium or aluminum, or it may be used in massive form. Massive UO_2 is usually clad to prevent fission product escape. When used in massive form, UO_2 should be as dense as possible to assure the maximum number of fuel atoms per unit volume. Bodies having 96% of theoretical density have been prepared by isostatic pressing and sintering at 1750 C for 1 hr. The radiation stability of UO_2 appears satisfactory.

UO_2 dispersed in aluminum is used as the fuel element in the Geneva Conference Reactor. These components, 18 in number, are in the form of plates containing 54% UO_2 in aluminum powder. UO_2 dispersed in stainless steel in the form of flat plates, 30 mils thick, clad in 5-mil stainless steel, which are 25 in. wide and 23 in. long are used in the North American Aviation pool type reactor designs. Massive UO_2 in pellet form contained in zirconium cladding is used in blanket assemblies in the PWR (Pressure Water Reactor).

UO_2 in austenitic stainless steel has been suggested for small water cooled and moderated plants.

UO_3-water slurries have been studied for reactor service. Their principal objection is the tendency of the material to cake on pipe walls at elevated temperatures. Their attack on stainless steel at 250 C is reported to be nil after circulation at a maximum velocity of 83 ft per sec at throat of orifice and 20 ft per sec in straight pipes and elbows.



***Corrosion of thorium** in air at various temperatures. Battelle Memorial Institute, July 1, 1952.*

PROPERTIES OF URANIA AND THORIA[c]

Formula	Urania	Thoria
Bulk Density, gm/cm³	10.02[a]	9.6[a]
Melting Point, C	2878 ± 22	3220 ± 50
Thermal Cond, cal/sec/cm²/C/cm 100C 600C 1200C	 0.018 0.008 0.006	 0.02 0 008 0.0076
Coeff of Exp per C	11.2 x 10^{-6}(27-1260C)	8 x 10^{-6} (20C) 9 x 10^{-6} (500C) 9 x 10^{-6} (1000C)
Mod of Elast, psi	25 x 10^6 (20C)	21 x 10^6 (20C) 18 x 10^6 (500C) 14 x 10^6 (1000C)
Spec Ht, cal/gm/C	0.056 (17C)	0.058 (50C)
Metal Atoms/cm³ in Oxide Compared with Metal, %	51.5	78.5
Preferred Methods of Fabrication[b]	I, II, III, IV	I, II, III

[a] Isostatically pressed and sintered
[b] Fabrication numbers:
I—Cast and sintered
II—Extruded and sintered
III—Cold pressed and sintered
IV—Hot pressed
[c] Source: "Refractories for Nuclear Energy," American Refractories Institute, Technical Bulletin No. 94, Feb 1956.

Thorium

Thorium is of major interest in reactor technology because it is a potential source of the secondary nuclear fuel U^{233} and the possibilities of "breeding" with thorium to increase the supply of fissionable materials is of major consideration to the successful development of commercial nuclear power.

Thorium in the finely divided state is pyrophoric, and its handling in this form requires special precautions. Its corrosion resistance is poor in air and water, especially at elevated temperatures.

Thorium belongs to the cubic system, which means that its properties will be isotropic in comparison with the anisotropic behavior of uranium over a wide temperature range. A phase change from face-centered cubic to body-centered cubic has been reported between 1400 and 1500 C.

Thorium can be fabricated by a variety of standard methods including forging, extrusion, hot and cold rolling, swaging and drawing. It is ductile and can be subject to considerable reduction before annealing becomes necessary. At lower temperatures it is semibrittle under impact but becomes tough at 250 C. Its machining characteristics are similar to mild steel. Exclusion of air is necessary to prevent oxidation during fabrication. No very successful technique has been developed for joining thorium to thorium or other metals.

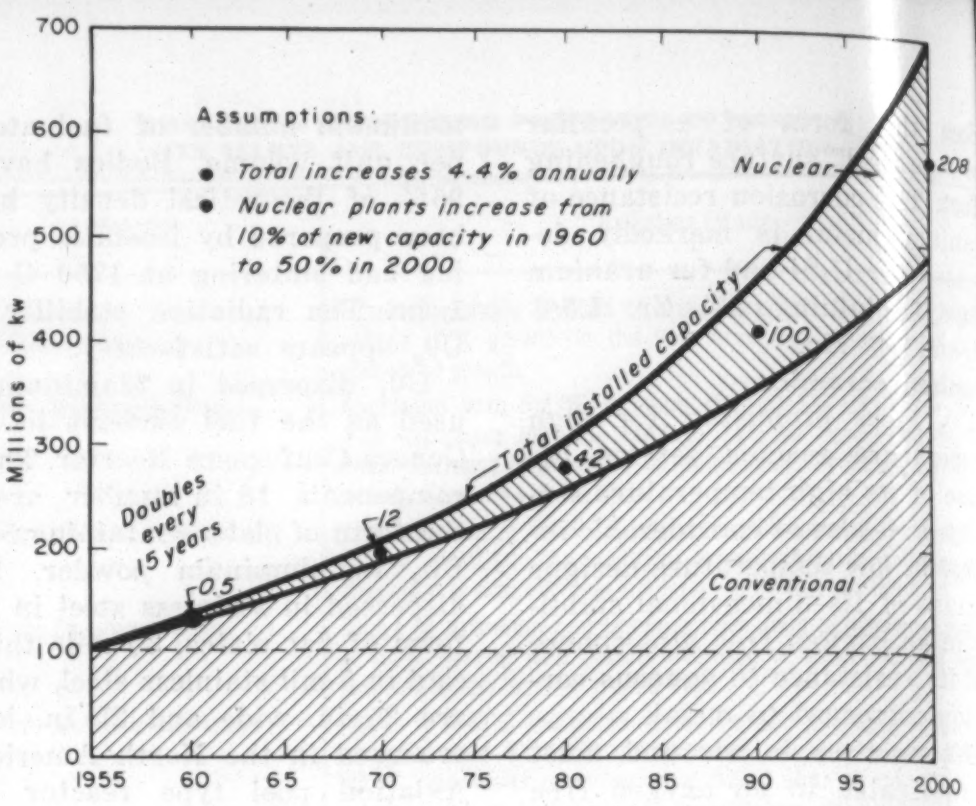
Thorium alloy development for the purpose of improving mechanical and corrosion properties has led to the discovery of the hardening effect of carbon in small quantities and the improved aqueous corrosion resistance of 25 to 30% by weight of zirconium. Intermetallic compounds of thorium with other metals give rise to alloys that are appreciably stronger than thorium alone.

Thorium exhibits excellent radiation stability as a result of its isotropic nature. No growth occurs after an exposure of 10^{19}nvt.

Thorium oxide

Thorium oxide (ThO_2) is of potential interest as a breeder material in a high temperature reactor because of its refractoriness. High density is also a requirement for solid thoria and shapes having a density of 96% of theoretical have been fabricated by sintering ThO_2 with 0.5% CuO at 1700 C for 1 hr. Combinations of UO_2 and ThO_2 have been suggested for use in thermal breeder reactors.

Aqueous slurries of ThO_2 have been considered for breeder reactor applications. Caking on pipe walls is a problem during circulation at 250 C when impurities are present and there is a tendency to form plastic mixtures below 200 C on violent agitation. Oxalic acid additions have been found to reduce the viscosity of plastic slurries at room temperature. Abrasion-corrosion problems are encountered in regions of high fluid acceleration.



Projected growth *of conventional and nuclear power in the U.S. indicates that by 2000 A.D. nuclear power plants will be generating more power than all sources in 1955 combined.* (Babcock & Wilcox Co.)

Future Outlook

The nuclear chain reaction is independent of temperature and consequently reactor technology leading to the production of cheap, reliable and safe nuclear power can proceed along either the high temperature-high thermal efficiency path or the low to moderate temperature-low thermal efficiency pattern. As long as present limitations of existing materials persists, the latter approach will prevail. Development along the former avenue requires new materials and new design concepts. This approach because of the greater unknowns involved, may be expected to proceed slowly.

The three metals now available where neutron economy is essential are zirconium, beryllium and aluminum. Only zirconium and beryllium are suitable for service at higher temperatures but zirconium costs $30 per lb and beryllium $175. To make adequate use of these essential metals in commercial power reactors their costs must come down.

Where neutron economy is not of primary importance, available metals are stainless steel, molybdenum, titanium and nickel. Improvements in the mechanical properties of these materials may be expected to broaden their usefulness.

The currently most widely studied reactor designs are the water cooled types because water is cheap, its nuclear properties are acceptable and the technology connected with its use at high temperatures and pressures is well known. Corrosion of metal components may be expected to be a limiting factor in the development of this class of reactors and of the liquid metal cooled and other liquid cycle types. The gas cycle reactor being constructed in Britain appears to offer advantages in safety and freedom from corrosion but some U. S. observers question the efficiency of such systems for large-scale power production.

Clues to the building of more economical reactor systems lie in the development of more durable fuel elements and more efficient moderators. Lighter shields are needed for mobile reactor applications. Such technology requires a long time to acquire and is expensive, but it is in these areas that long-range research can pay off handsomely. The supplier who has the most know-how will get the business. Radical new concepts of reactor design may be expected as knowledge of materials suitable for reactor construction increases.

Reprints of this Manual are available at 50c each until supply is exhausted. See page 230 for complete list of available Manuals. Write for quotations on quantities of 100 or more. Address requests to Reader Service Dept., MATERIALS & METHODS, 430 Park Ave., New York 22, N. Y.

MATERIALS ENGINEERING FILE FACTS

Selection and Applications of Spring Materials (Continued from July)

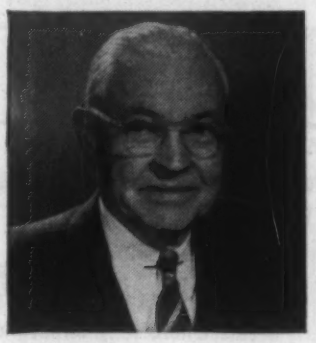
Materials (Commercial Name)	Characteristics and Applications	Available Sizes	Application Temp, F	General Properties
Alloy spring steels have a definite place in the field particularly for conditions involving high stress and for applications where shock or impact loadings occur. They can withstand higher and lower temperatures than high carbon steels and are obtainable either annealed or pretempered.				
Chromium-Vanadium (SAE 6150)	Most popular alloy spring steel. Used extensively for aircraft engine valve springs.	Dia 0.031-0.500 in. and some larger sizes. Square sizes in fractional dimensions.	Max 425	For higher stresses than can be handled by high carbon spring steels where long endurance life is needed. Also for shock or impact loading.
Silicon-Manganese (SAE 9260)	Less expensive than chromium-vanadium, used extensively in flat leaf springs for trucks.	Round, square and rectangular sections from 0.031-0.500 in.	—	—
Chromium-Silicon (SAE 9254)	Developed originally for recoil springs for anti-aircraft guns.	Dia 0.031-0.500 in.	Max 475	Can be heat treated to higher hardnesses than other spring steels. Rockwell C50 to C53 common. For highly stressed springs requiring long life under shock loading.
Chromium-Molybdenum-Vanadium	Helical springs for piston rod packings in locomotives.	Round, square and flat sections.	To 800 and slightly higher.	Modified tool steel to be hardened and tempered after forming.
Chromium-Molybdenum-Nickel (AISI 8650 & 8660)	Used in large sections for hot formed springs in railroad cars.	8650 grade in sections to 1 in.; 8660 grade from 1 to 2 in.	—	—
Special nickel alloys having a constant modulus of elasticity over a wide temperature range are desirable for springs subjected to temperature changes; especially where the springs must exert uniform loads and deflections. These corrosion resistant alloys having uniform and nearly constant elastic characteristics also have low hysteresis and low creep values, making them preferred materials for food weighing scales, precision instruments, gyroscopes, measuring devices, recording instruments and computing scales where temperature changes are within the range of −50 to 150 F. These materials are quite expensive and not regularly stocked in a wide variety of sizes. They should not be specified without prior discussion with spring manufacturers because some suppliers may not fabricate springs from these alloys. All these alloys are covered by U. S. patents.				
Elinvar	Hair springs in watches.	Small wire dia and thin strip only.	150 to −50	Hardened only by cold work.
Ni-Span C	Most popular of constant modulus alloys.	Same as Elinvar	Same as Elinvar.	Usually formed in 50% cold worked condition and precipitation hardened to Rockwell C40-C44. Useful at torsional stresses of 60,000-80,000 psi.
Iso-Elastic	Used in dynamometers, instruments and food weighing scales.	Same as Elinvar.	Same as Elinvar.	Safe torsional stresses 40,000-60,000 psi at hardness values of Rockwell C30–C36.
Elgiloy, 8J Alloy, Durapower, Cobenium	Used in instruments and Elgin watches.	Same as Elinvar.	Max 1000; useful at subzero temperatures.	Precipitation hardened to Rockwell C48–C50.
Dynavar	Used in instruments and Hamilton watches.	Same as Elinvar.	Max 750; useful at subzero temperatures.	Precipitation hardened to Rockwell C48–C50.

(continued on p 149)

For more information, Circle No. 532

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY



Technical-ities

By John S. Davey

The Proper Loading of Bolts

The pre-load, or residual tension, in a tightened bolt means more to assembly strength than the actual strength of the bolt itself.

In a joint, a bolt torqued to its proper load level resists a maximum amount of external load without loosening. Designers can take advantage of this fact and assure better results, and at the same time, cut costs.

For example: One designer calculated that truck frames needed high strength bolts at least ½" in diameter. So he used ⅝". But on the assembly line, these were being torqued to 100 ft.-lbs. whereas they needed at least 200 ft.-lbs. for proper residual tension. The ½" bolt at 100 ft.-lbs. would actually have given the stronger assembly and at less cost.

In another case, the bucket on earth moving equipment was always coming loose. The design engineer kept increasing the size of the bolt up to 1¼", but to no avail. The impact wrench used was supplying far too little torque for this size. We suggested a return to the original ¾" bolt used, set up to 350 ft.-lbs. torque. It solved the problem.

In short, the more you stress a bolt within its elastic limit, the greater its ability to stay tight and make a strong assembly.

Symmetrical flow lines assure strong bolt heads

Photo of perfect cold worked blank after first upset.

Effect of improper forming is a poor head like this.

IN THE manufacture of bolts and cap screws, the first upset of metal is a vital one. It determines the flow lines in the bulb which will form the head. A symmetrical flow assures no laps and, therefore, no weak spots or cracks in the final upset of the head.

MACHINE OPERATOR'S SKILL VITAL

The upper photo shows a longitudinal section of a blank after the first upset and on its way to becoming an RB&W standard bolt. Note the even distribution of flow lines. This bulb will become a perfect head.

The lower photo shows what can happen with poor tools, inexperienced operators or without precision setup of the cold headers. Note how pronounced is the unbalanced flow pattern which resulted from a bulb with just a minute defect.

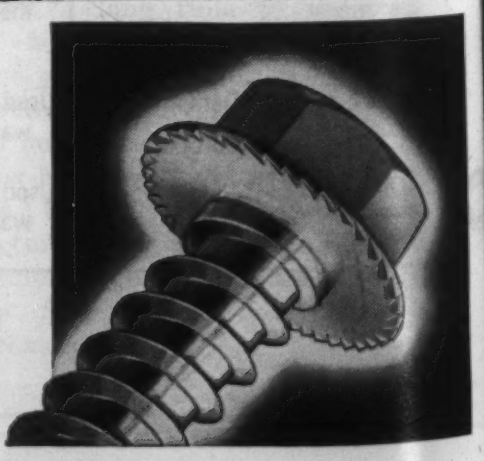
DEPENDABLE FASTENERS

Cap screws and bolts also get a bright smooth finish from the right kind of cold forming. But above all, they offer the designer low cost fasteners with sound internal structure. Standard RB&W fasteners can be loaded to their proper level —become a strong point in any assembly.

For help on your fastener problem, contact Russell, Burdsall & Ward Bolt and Nut Company. Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

The Only Screw That Stays Tight

The continual heating and cooling caused loosening of handle screws on the flat irons of one manufacturer. Every type tried failed to stay tight until RB&W's unique Spin-Lock tapping screws were used. This solved the problem. Their hardened teeth lock into the surface, require more torque to loosen than to tighten. One piece fasteners, they speed assembly time.



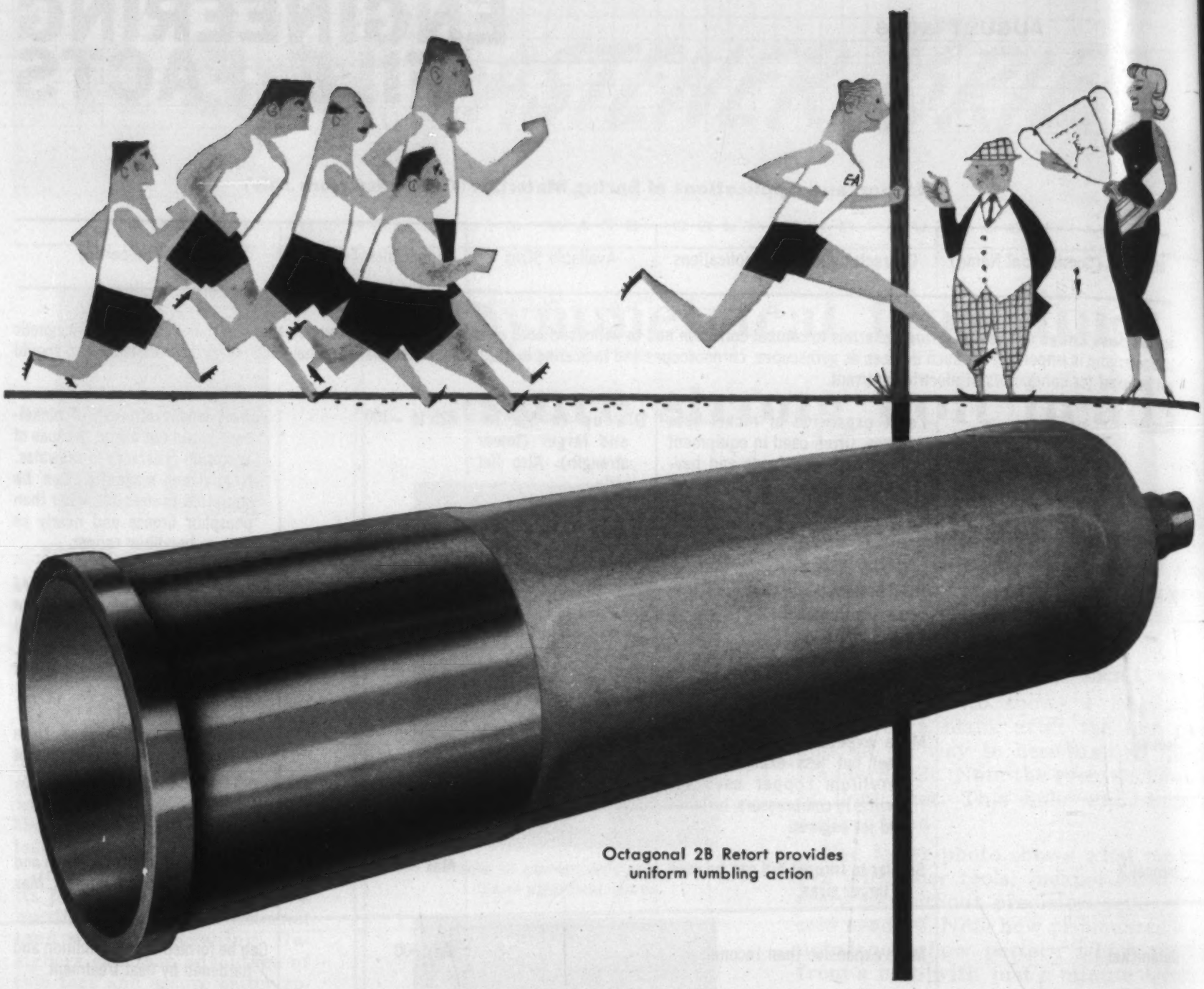
For more information, turn to Reader Service Card, Circle No. 504

MATERIALS ENGINEERING FILE FACTS

Selection and Applications of Spring Materials (Concluded from July)

Materials (Commercial Name)	Characteristics and Applications	Available Sizes	Application Temp, F	General Properties
Nickel-base alloys are useful spring materials to combat corrosion and to withstand both elevated and sub zero temperature applications. Their non-magnetic characteristic is important for such devices as gyroscopes, chronoscopes and indicating instruments. These materials have high electrical resistance and should not be used for conductors of electrical current.				
Monel	Least expensive of nickel-base alloys. Often used in equipment in contact with foods and beverages.	Dia up to 3/16 in. and larger (lower strength). Also flat strip.	425 to −100	Lowest tensile strength of nickel-base group but useful because of corrosion resistance to seawater. Nearly non-magnetic. Can be subjected to stresses higher than phosphor bronze and nearly as high as beryllium copper.
K-Monel	Used in sizes larger than ordinarily used with Monel.	—	450 to −100	Formed in soft or partially hard condition, age-hardened to obtain tensile strength above Monel and nearly as high as stainless steel. Max working stress usually 45,000 psi.
Inconel	More expensive than stainless steel but less expensive than beryllium copper used for springs in compressors, turbines and jet engines.	Dia up to ¼ in.	Max 700	Tensile strength higher than K-Monel by cold working. Cannot be hardened by heat treatment.
Inconel X	Similar to Inconel but can be used in larger sizes.	—	Max 850	Can be formed in soft condition and hardened by heat treatment. Max working stress 55,000 psi.
Duranickel	More expensive than Inconel.	—	Max 500	Can be formed in soft condition and hardened by heat treatment.
Copper-base alloys are important spring materials because of their good electrical properties combined with their excellent resistance to corrosion. Although these materials are more expensive than the high carbon and the alloy steels, they nevertheless are frequently used in electrical components and in subzero temperatures. All copper-base alloys are drawn to the American Wire Gage (same as Brown & Sharpe Gage) and are non-magnetic.				
Spring Brass (70 Cu–30% Zn)	Least expensive and highest electrical conductivity of the group. Used extensively in flat stampings.	Round sections and flat strip.	Max 150; useful at sub-zero temperatures.	Low tensile strengths. Cannot be hardened by heat treatment usually used in spring temper.
Phosphor Bronze (5% Sn)	Most popular alloy of group. Used for contact fingers in switches because of low arcing characteristics and many other applications.	Round sections and flat strip.	Max 212; useful at sub-zero temperatures.	Can withstand stresses 50% higher than brass. Cannot be hardened by heat treatment usually used in extra hard or spring tempers.
Beryllium Copper (2¼% Be)	Most expensive of group. Major use current carrying springs in electrical components and switches.	—	—	Formed in soft condition and precipitation hardened to produce high strength.
Copper-Manganese, Nickel-Silver, Cupro-Nickel	Used for contact fingers and other electrical spring applications as alternates for other copper-base spring materials.	—	—	All three are white and often are selected for color harmony. Good corrosion resistance.
Silicon-Bronze, Aluminum-Bronze, Tin-Brass	Useful for special applications.	—	—	Good corrosion resistance.

Adapted from a paper by Harold C. R. Carlson delivered at the ASME Diamond Jubilee Meeting, Chicago, Ill., Nov., 1955.



Octagonal 28 Retort provides uniform tumbling action

PERFORMANCE "PAYS OFF"

Thermalloy* Retorts pay off with longer service life

Thermalloy high-alloy Retorts retain structural strength and resist atmospheric attack at extremely high temperatures.

For example, at a large ball and roller bearing company, Thermalloy octagonal retorts, similar to the one shown in the above illustration, gave 30% more wear life.

Thermalloy is not a single alloy, but a *group* of tough heat-resistant alloys developed specifically to meet a specific high heat-treat problem.

Wherever heat-treat parts are highly or indeterminately stressed . . . subject to thermal fatigue . . . Thermalloy pays off in longer service life with less maintenance.

Let us show you how our engineering skill and design experience on furnace and heat-treat parts can save you money! Contact your local Electro-Alloys representative or write Electro-Alloys Division, 7028 Taylor Street, Elyria, Ohio.

*Reg. U. S. Pat. Off.

HEAT-RESISTANT CASTINGS • TRAYS • MUFFLES • CONVEYOR BELTS • RETORTS • RADIANT TUBE

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
Elyria, Ohio

For more information, turn to Reader Service Card, Circle No. 465

NEW MATERIALS PREVIEWS

This month

- *Alloys for 1000-1650 F*
- *New designs in expanded metals*
- *Other new materials, p 155*

Aircraft, industrial gas turbine applications for ...

Two High Temperature Nickel Alloys

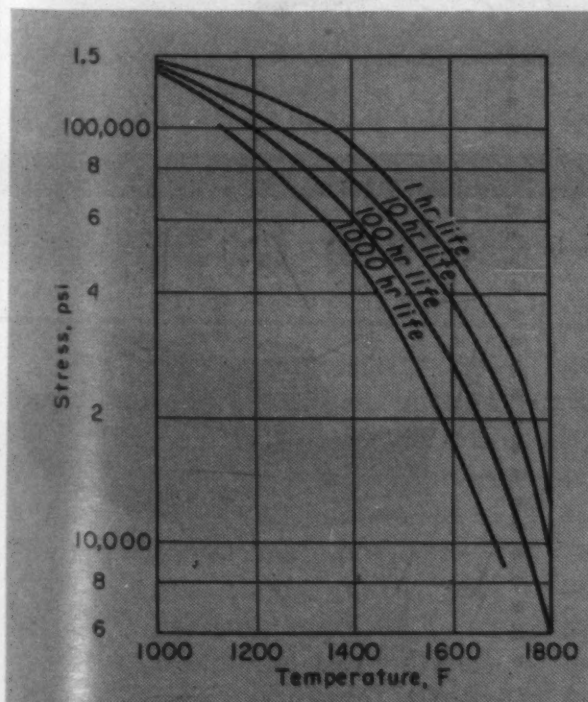
PHYSICAL PROPERTIES OF INCONEL 700 AND INCOLOY 901

Alloy	Density, lb/cu in.	Modulus of Elasticity		Coefficient of Thermal Expansion.	
		Temp, F	Modulus, psi	Temp, F	Coefficient, per deg F
Inconel 700	0.295	70	32. x 10^6	70–200	6.48 x 10^{-6}
		1000	27. x 10^6	70–1000	8.02 x 10^{-6}
		1500	24. x 10^6	70–1400	8.68 x 10^{-6}
		—	—	70–1600	9.27 x 10^{-6}
Incoloy 901[a]	0.297	75	29.9 x 10^6	80–200	7.75 x 10^{-6}
		1000	24.2 x 10^6	80–1000	8.50 x 10^{-6}
		1200	22.1 x 10^6	80–1400	9.15 x 10^{-6}
		—	—	80–1500	9.43 x 10^{-6}

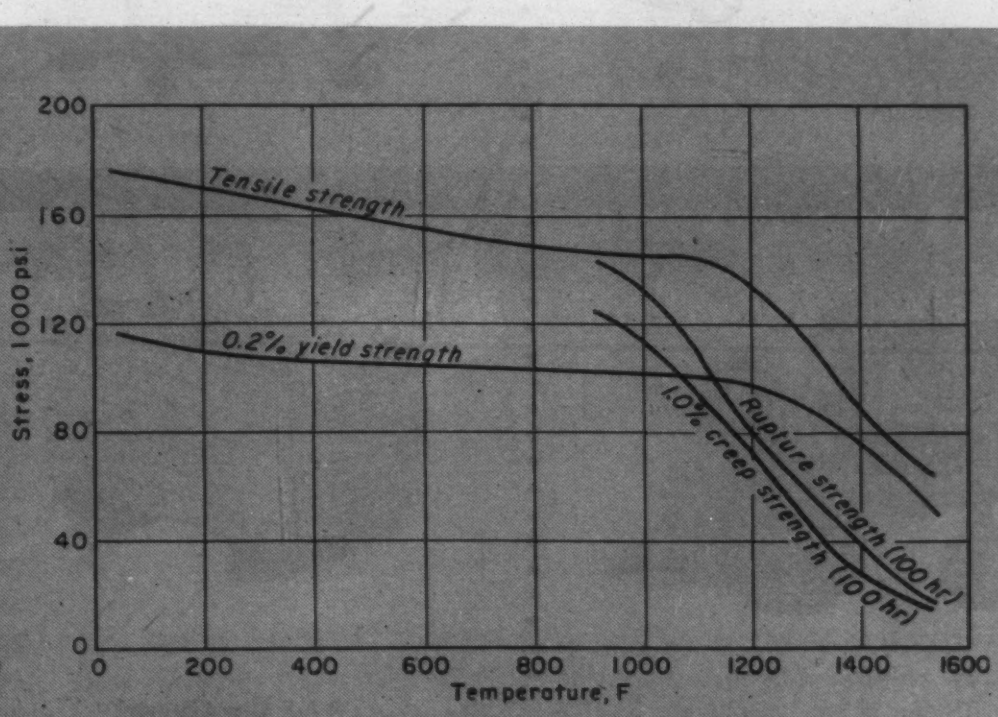
[a] Incoloy 901 undergoes a slight contraction during the 1300 F aging treatment. The amount varies, but is on the order of 0.1%.

■ Two new high temperature alloys for aircraft and industrial gas turbine applications have been announced by *International Nickel Co., Inc.*, 67 Wall St., New York 5.

The first, "Inconel 700" age-hardenable nickel - cobalt - chromium alloy, contains about 50% nickel and 30% cobalt. Inco developed this new alloy for aircraft designers who were seeking adequate strength in forged aircraft gas turbine blades at temperatures up to 1650 F. It is now pro-



Rupture strengh *of nickel-cobalt-chromium alloy, Inconel 700.*



Tensile properties *of nickel-iron-chromium alloy, Inconel 901, developed for aircraft and industrial gas turbines.*

MAKE IT WEIGH LESS

N-A-X

HIGH-TENSILE STEEL

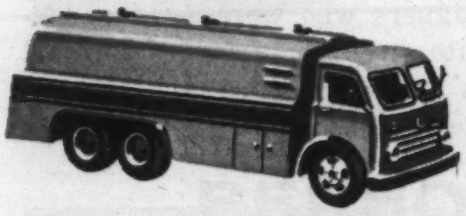
MAKE IT LAST LONGER

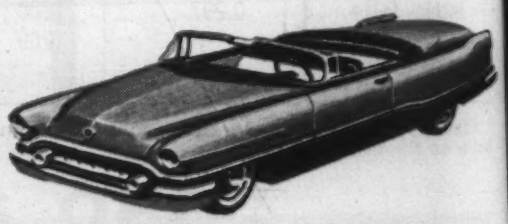
You can design light weight, longer life, and economy into your products by including N-A-X HIGH-TENSILE in your plans.

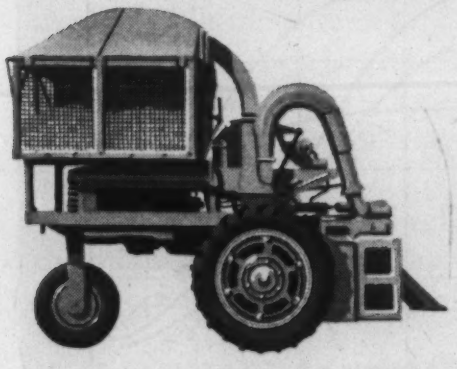
- It is 50% stronger than mild steel.
- It is considerably more resistant to corrosion.
- It has greater paint adhesion with less undercoat corrosion.
- It has high fatigue life with great toughness.
- It has greater resistance to abrasion or wear.
- It is readily and easily welded by any process.
- It polishes to a high lustre at minimum cost.

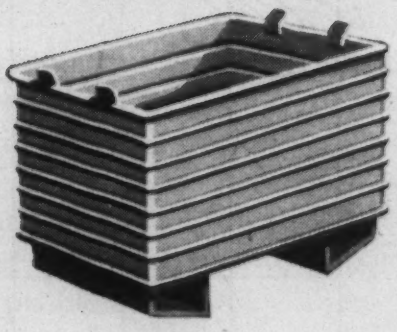
And with all these physical advantages over mild carbon steel — it can be cold formed as readily into the most difficult shaped stamping.

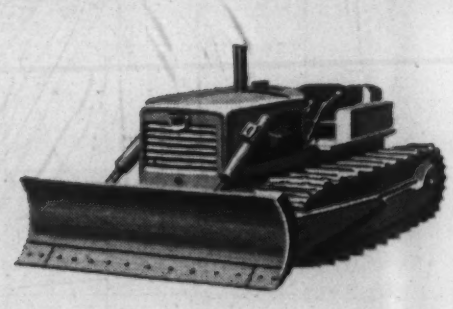
When you next start to redesign, get the facts on N-A-X HIGH-TENSILE. It's produced by Great Lakes Steel — long recognized specialists in flat-rolled steel products.











N-A-X Alloy Division

GREAT LAKES STEEL CORPORATION

Ecorse, Detroit 29, Mich. • A Unit of

NATIONAL STEEL CORPORATION

For more information, turn to Reader Service Card, Circle No. 488

duced as hot rolled rounds of 5/8 to 2-in. dia. All rods are furnished with a turned or ground finish. Mechanical properties of Inconel 700 alloy at 1650 F are similar to those of Inconel X at 1500 F.

Inco developed the second product, "Incoloy 901" nickel-iron-chromium alloy, for aircraft and industrial gas turbine components requiring high creep and rupture strength at 1000 to 1400 F. Incoloy 901 alloy at these temperatures has properties that compare favorably with those of the super alloys, yet it is low in strategic alloy content.

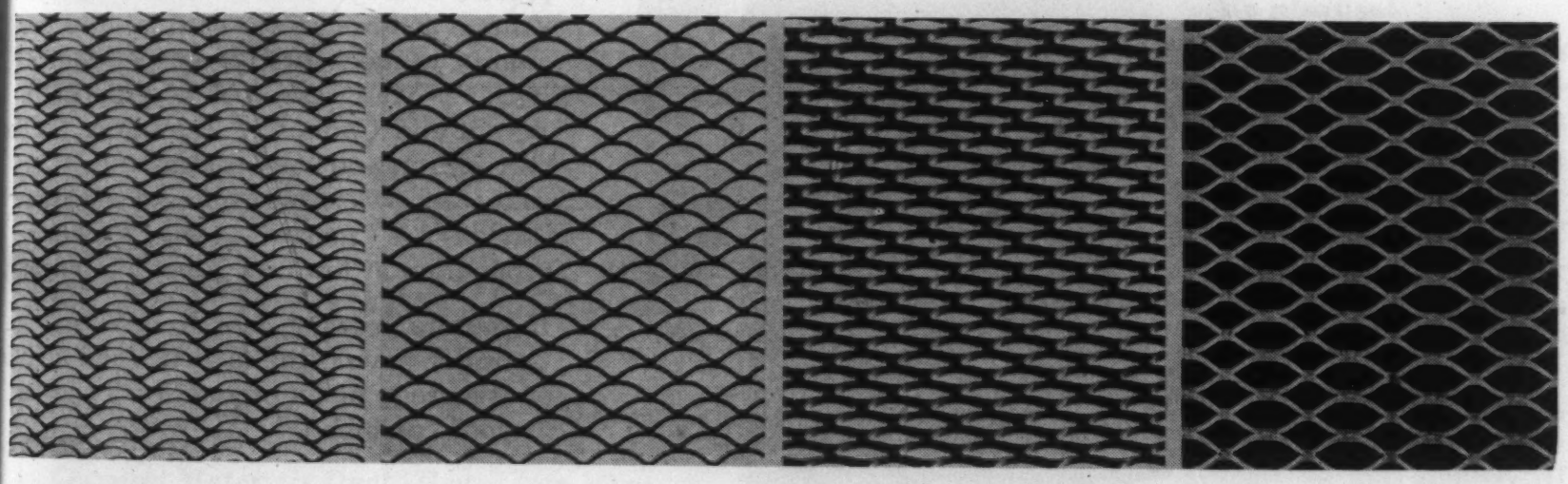
An important physical property of this second alloy is its low coefficient of thermal expansion. Containing about 40% nickel, it is similar enough to ferritic alloy steels to permit the two materials to be joined without special provision for thermal expansion.

In addition to bar and forging stock, the alloy is also produced as sheet in the same sizes and gages as those offered in Inconel X and Inconel W age-hardenable alloys. Incoloy 901 is expected to find use in turbine rotor and compressor disks and structural parts to operate in the intermediate temperature range of 1000 to 1400 F.

HIGH TEMPERATURE TENSILE PROPERTIES OF INCONEL 700[a]

Temp, F	Prop Limit, psi	Yield Str (0.2% offset), psi	Tensile Str, psi	Elong, %	Red of Area, %
80	69,000	104,000	171,000	25	27
1000	67,000	95,000	147,000	28	30
1200	65,000	92,000	146,000	23	27
1350	47,000	92,000	135,000	14	15
1500	42,000	75,000	107,000	6	8
1600	44,000	56,000	84,000	7	8

[a] Rod stock, 13/16 in. dia, solution treated 2 hr at 2160 F, air cooled and aged 4 hr at 1600 F.



New patterns *have endless uses. Left to right: Wavelength, Festoon, Armorweave and Rondo.*

Expanded Metals—New Patterns for New Products

Until recently, industrial designers using expanded metals were limited to a standard diamond-shaped pattern. Consequently, the material has been used for functional purposes—metal lath, machinery guards, catwalks and landing mats.

Now new flat and three-dimensional patterns are available from *U.S. Gypsum Co.*, 300 W. Adams St., Chicago 6. The patterns—Rondo, Festoon, Wavelength and Armorweave—are designed for decorative purposes. They are lightweight and have greater strength and rigidity than the solid metal sheets from which they are slit and cold drawn in continuous patterns. They are made in carbon steel, aluminum and, in some meshes, stainless steel. They may be coated, used in their natural finish or painted in various color combinations.

Applications include chairs, screens, radio and television grilles, wastebaskets, bookshelves, partitions, display boards, industrial baskets, ventilator panels, filter screens and sorting bins.

Easy to handle, the expanded metals can be cut with shears, bolt cutters, pliers or torch without raveling. The sheets can be joined to other units readily by resistance welding, arc welding or brazing.

(Other New Materials on p 155)

Are you "outgrowing" your present source for castings?

CWC supplies low cost, precision castings in volume to expanding industries!

Growth and expansion! That is the pattern of business today. Naturally, this creates problems, and often one of them is casting supply. Many firms have outgrown their present source—need castings in greater volume at lower costs—and even higher quality to meet today's competition.

If this is your case, look to Campbell, Wyant and Cannon . . . the source for the best in iron and steel castings . . . where expert engineering and precision controls are "musts" . . . where volume production at low cost is not a problem.

If you are growing, look to CWC! Consider having the facilities and abilities of this group of six production foundries at your command.

campbell wyant and cannon

FOUNDRY COMPANY

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Muskegon, Michigan

CWC

Write for the "One Source" story today!

This informative booklet tells why CWC should be the "One Source" for all your grey iron, iron alloy, and steel casting needs. Write for a copy today!

For more information, Circle No. 540

SIX FOUNDRIES LOCATED IN MUSKEGON, LANSING AND SOUTH HAVEN, MICHIGAN . . . READY TO SERVE YOU!

AVERAGE PROPERTIES OF NEW MOLDING COMPOUNDS

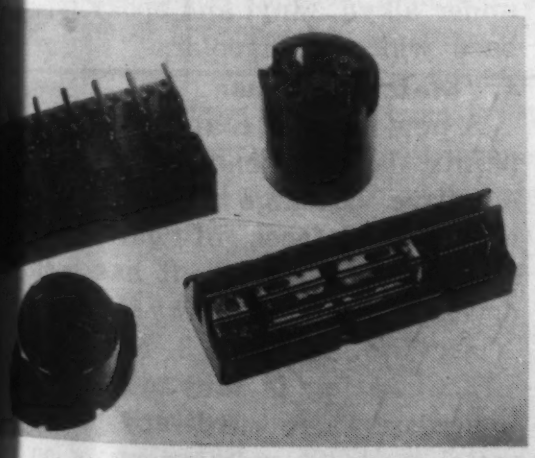
Property	GE 12902	GE 12920	GE 12921
Color	black	black	brown
Izod Impact, ft-lb/in. of notch	0.36	0.34	0.32
Flexural Strength, psi	10,000	10,000	10,000
Modulus in Flexure, psi	1×10^6	1×10^6	1×10^6
Tensile Strength, psi	7500	6500	6500
Compressive Strength, psi	30,000	33,000	25,000
Specific Gravity	1.39	1.37	1.40
Water Absorption, % in 48 hr	0.8	0.75	0.75
Shrinkage, mils/in.	6	7	7
Hardness, Rockwell M	110	115	100
Heat Distortion Point, F	350	300	300
Dielectric Strength (short time, 60 cycles), v/mil:			
at 77 F	250	250	300
at 212 F	175	100	100
Power Factor (dry):			
60 cycles	0.1	0.55	0.30
1000 kc	0.05	0.05	0.06
Dielectric Constant (dry):			
60 cycles	9	13	10
1000 kc	6	5	5
Volume Resistivity, ohm-cm units	1.5×10^6	4×10^5	3.5×10^5
Insulation Resistance, megohms	600	2×10^4	5.5×10^4

Versatility, rapid cure rates with . . .

Three Phenolic Molding Materials

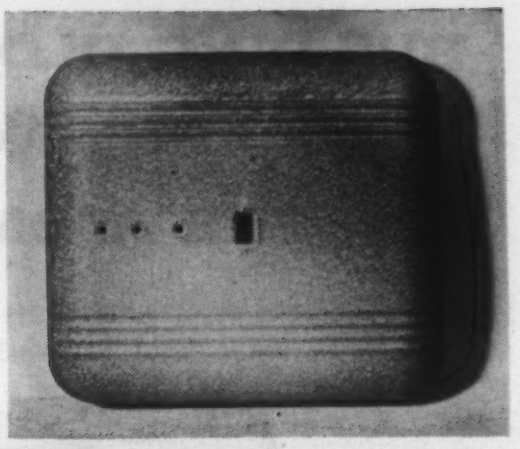
Three new phenolic molding compounds have been developed by *Chemical Materials Dept., General Electric Co.*, Pittsfield, Mass.

A one-stage black phenolic molding compound, designated GE 12902, offers faster cure rates to step up molders' production cycles. The compound is reported to have good release characteristics, low bulk factor and uniform granulation. Successful applications include refrigerator and range parts, distributor caps and rotors, and automotive switch parts.



Switch components *molded with new one-stage phenolic molding compounds.*

The other compounds are two-stage materials. GE 12920 is available in black and GE 12921 in brown. Both have been formulated for increased versatility and rapid cure. They are being molded into wiring devices, range switches and other electrical parts, as well as iron handles and photographic parts.



***Wrinkle pattern** is obtained from plastisol applied by spraying.*

Decorative, Functional Coatings Announced

Recent developments in coatings include a wrinkle plastisol, a ceramic coating that protects metals up to 1100 F, an epoxy size and a conductive coating for nonmetallic materials. These and seven other new coatings are described below.

1. Wrinkle plastisol

A new wrinkle plastisol has been introduced by *Stanley Chemical Co.*, East Berlin, Conn., as a finish for typewriters, business machines and other mechanical devices. The 100% solids material is applied by spraying. Hardness and resistance to abrasion, chemicals and perspiration are claimed to be excellent.

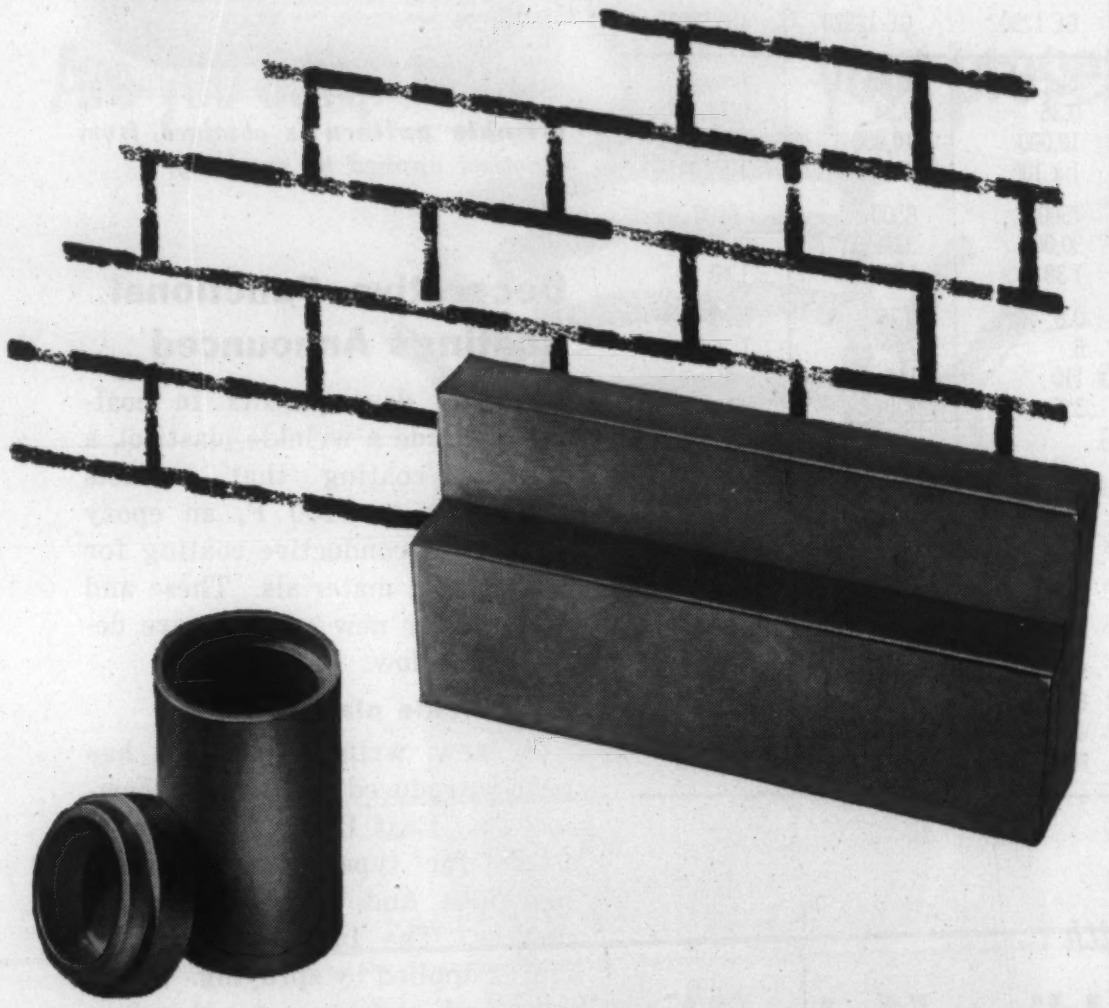
To obtain the wrinkle pattern, a coating of 8 to 10 mils of plastisol is applied on the primer. It can also be applied to vertical surfaces without sagging and to smooth surfaces such as paper and foil.

2. Ceramic coating

A water base ceramic coating that protects metal surfaces against elevated temperature corrosion up to 1100 F has been developed by *Kraus Research Laboratories*, Cockeysville, Md. The cured coating has good impact and shock resistance. Called Porcelox, it is unaffected by oxidation or sunlight and presents no fire hazard.

The coating is used on iron or steel exhaust manifolds, exhaust pipes, mufflers and fire doors. It

BUILDING BLOCKS AND CARRYING CASES FOR THE ATOMIC AGE



Lead is the most readily available, efficient protection against atomic radiation.

Interlocking lead bricks, developed in Federated's laboratories, are now available for easy-to-construct radiation shielding. Small lead bottles, designed and made by Federated, safely transport the isotopes used for medical or industrial purposes.

Federated lead and lead alloys are used by many other industries . . . plumbing for residential and industrial construction; piping, lining and valves for handling corrosive chemicals; anodes for metallic plating. The company is constantly working to improve lead products and increase their usefulness. At Federated's Research Laboratories, some lead samples have been under test continuously for more than 20 years.

When you need reliable lead products or other non-ferrous alloys; or expert advice on their applications, call your nearest Federated Sales office. Our work with these metals has earned us our reputation as Headquarters for Non-Ferrous Metals.

Federated Metals

DIVISION OF AMERICAN SMELTING AND REFINING COMPANY
120 BROADWAY, NEW YORK 5, N. Y.
In Canada: Federated Metals Canada, Ltd., Toronto and Montreal

Aluminum, Anodes, Babbitts, Brass, Bronze, Die Casting Metals, Lead and Lead Products, Magnesium, Solders, Type Metals, Zinc Dust

For more information, turn to Reader Service Card, Circle No. 470

OTHER NEW MATERIALS PRODUCTS

may be applied to pottery, glass and other materials capable of standing curing at an oven temperature of 450 F for 15 min. In special cases, such as exhaust manifolds and fire doors, curing is accomplished automatically in service. The coating may be brushed, sprayed or dipped. Two coats, which are usually desirable, have a thickness of 6.5 to 13 mils.

Porcelox is available in black and dark green and also in a graphited formulation that furnishes lubrication where hot metal surfaces slide or rub together. The material will withstand flame impingement when there is provision for heat removal to prevent temperature from exceeding 1100 F. Porcelox is not recommended for: 1) light gage metal areas subject to flexing, 2) applications where strong acids and alkalies are in constant contact, or 3) a paint base, as it is not compatible with organic paints.

3. Epoxy size

An epoxy size coating for metals, developed to minimize differences in tin plate conditions, provides a suitable surface for subsequent organic coatings. Based on an epoxy ester resin, it is available from *Watson-Standard Co.*, 231 Galveston Ave., Pittsburgh 12.

Applications include screw caps, crowns, closures and cans. The size coating, designated Watson-Standard 17-331, can be used under alkyd, vinyl and epoxy type base whites and colors.

4. Metallic primer

A new metallic coating prevents paints, lacquer, enamel or other siccative coatings from peeling off the surfaces of galvanized metal. Called Metco, it has been developed by *Solfo Paint Mfg. Co., Metco Div.*, Trenton 3, N. J.

The coating is said to make it unnecessary to use any other metal wash or priming agent on galvanized metal. Colorless, nonflammable and odorless, it may be applied by a brush or cloth.

(continued on p 158)

For more information, Circle No. 485

from GAF...high pressure acetylene derivatives with 3 centers of reactivity

$HC{\equiv}CCH_2OH$ Propargyl Alcohol

a chemical intermediate and corrosion inhibitor

NEW: ELIMINATES HYDROGEN EMBRITTLEMENT

Low concentrations of propargyl alcohol in acid pickling baths inhibit or completely eliminate hydrogen embrittlement. Bend angles of 180° are obtained in a modified Zapffe method of testing. A special data bulletin is available on request.

Concentration of Inhibitor Based on Acid Content, Per cent by Weight	DEGREE OF ARC OBTAINED			
	Propargyl Alcohol	2-butyne-1, 4 diol	Commercial Inhibitor "A"	Commercial Inhibitor "B"*
0.00	69	69	69	69
0.25	180	48	43	68
0.5	180	54	36	180
1.0	180	59	77	123
2.0	180	150	103	145
4.0	180	123	66	133
8.0	180	130	133	180

*Contains 11% propargyl alcohol.

chemical intermediate:

Propargyl alcohol, $HC{\equiv}CCH_2OH$, with its three centers of reactivity, primary alcohol, triple bond and active hydrogen, has proven itself a valuable tool in the synthesis of pharmaceuticals, essential oils, agricultural and specialty chemicals.

corrosion inhibitor:

Propargyl alcohol is an excellent corrosion inhibitor for mineral acids and stabilizer for chlorinated solvents.

properties:

Propargyl alcohol is a colorless, stable liquid, infinitely miscible in water, benzene, ethanol and other organic solvents.

$HC{\equiv}CCH_2Br$ Propargyl Bromide

a chemical intermediate and agricultural soil sterilizer

chemical intermediate:

Propargyl bromide, $HC{\equiv}CCH_2Br$, has three centers of reactivity; triple bond, bromine atom, and acetylenic hydrogen. Synthesis of terpinoid structures such as vitamin A, plant growth hormones, etc., is possible through Reformatsky-type reactions. Some propargyl amines and propargyl ethers synthesized from propargyl bromide have physiologic activity as morphine antagonists and hormones. Used in the synthesis of propargyl substituted barbiturates.

soil fumigant:

Propargyl bromide has been found to be highly effective as an agricultural soil fumigant.

properties:

Almost colorless liquid, insoluble in water, soluble in ethers, benzene and hydrocarbons.

For technical information, price schedules and samples write to:

ACETYLENE CHEMICALS DEPARTMENT

ANTARA® CHEMICALS

A SALES DIVISION OF

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From Research to Reality

RANSBURG
Electro-Spray
DOES IT
BETTER...
FOR LESS

Look what Ransburg Electrostatic Spray painting is doing in this eastern job shop, the Del-Val Finishers Division of J. W. Rex Company, Lansdale, Pa.

As a job shop, Del-Val handles a variety of work each month, painting hundreds of thousands of pieces and parts of various sizes and shapes.

The versatility and flexibility of Ransburg Electro-Spray makes it ideal for their varied painting requirements. Here's a typical example. Del-Val recently completed a contract for a Philadelphia manufacturer of barbecue trays with these results:

50% INCREASE IN PRODUCTION

50% SAVINGS IN LABOR and OVERHEAD

66% CUT IN PAINT COSTS, with improved, more uniform, and higher quality finish.

The job—flat sheet steel, 11" x 19"—enamel coated to withstand a 90 bend with sharp radius. Full coat one side; mist coat other.

WITH RANSBURG ELECTRO-SPRAY		BY FORMER HAND SPRAY	
Output, 375 panels per hour with 3 men		Output, 250 panels per hour with 4 men	
	per panel		per panel
Labor and overhead	.06	Labor and overhead	.12
Paint & lease cost	.017	Paint cost	.044
TOTAL COST	.077	TOTAL COST	.164

Want to know what Ransburg Electro-Spray can do for you in YOUR finishing department? Write for our new No. 2 Process brochure. It tells the WHAT & HOW of electrostatic spray painting, and with numerous production-line examples, shows how other manufacturers are cutting finishing costs... increasing production, and improving the quality of their work with Ransburg equipment. Too, we have available now a new movie, "The Big Attraction," a 27-minute sound and color film on electrostatic spray painting.

Ransburg ELECTRO-COATING CORP.
Indianapolis 7, Indiana

RANSBURG

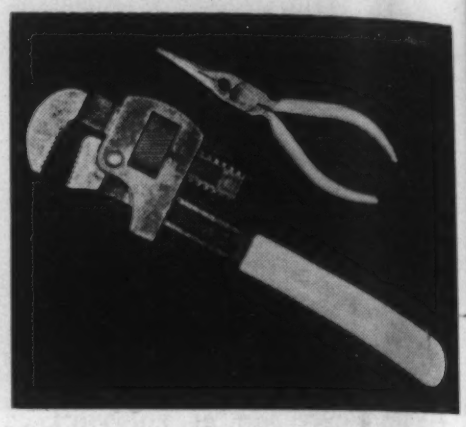
For more information, turn to Reader Service Card, Circle No. 457

OTHER NEW MATERIALS PRODUCTS

5. Dip vinyl coating

A resilient vinyl plastic coating for tool handles is marketed by *Beckett-Harcum Co., Plastics Div.*, 1087 Wayne Rd., Wilmington, Ohio.

The coating has high dielectric strength and is not dissolved by



***Resilient coating** for tool handles resists acids and alkalies.*

oils, greases, aliphatic hydrocarbons, alcohols or glycols. It is resistant to inorganic acids, alkalies, oxidizing agents and salt solutions at temperatures up to 200 F. Application requires only degreasing, a prime coat, preheating to 325 F and dipping.

6. Conversion coating

A conversion coating for aluminum and zinc that meets MIL C-5541 specification has been developed by *Oakite Products, Inc.*, 132H Rector St., New York 6. Called ChromiCoat, it improves paint adhesion and prevents corrosion.

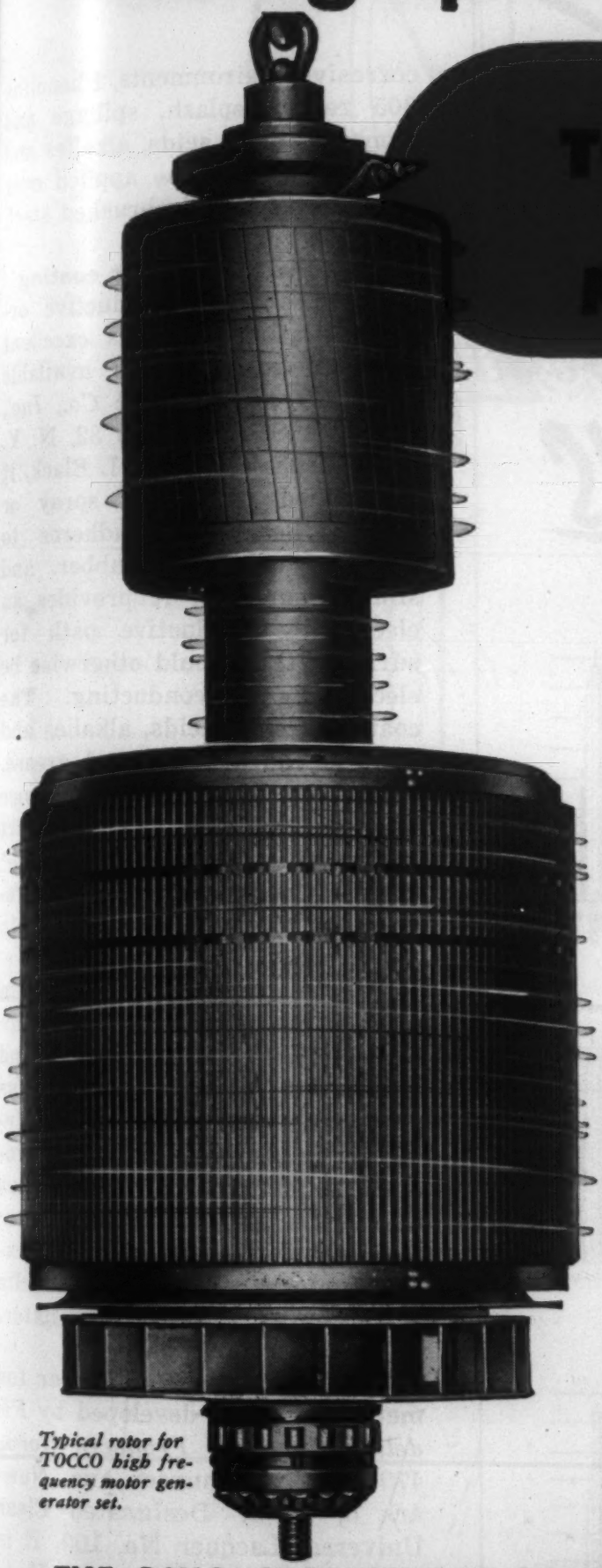
It is used at concentrations of 2 to 3 oz per gal of water at temperatures up to 100 F in either tank or washing machine.

7. Maintenance coating

A two-coat heavy duty maintenance coating with a total thickness of 12 mils is available from *Carboline Co.*, 331 Thornton Ave., St. Louis 19. Designated Phenoline 305, it is a modified phenolic, catalytically set. It has 86% solids content and provides a dense, nonporous film of 6 mils per coat. Coverage is 200 sq ft per gal.

Used for protection in severe

"Nothing Spins Like a Top"... *except*



Typical rotor for TOCCO high frequency motor generator set.

TOCCO'S VERTICAL Hi-Frequency Motor-Generator Sets

First with Vertical MG Sets—*TOCCO*

In 1943 TOCCO designed and built the first vertical motor-generator sets for furnishing hi-frequency power for induction heating applications. Now with thirteen years of continuous production experience, we are far and away the world's largest supplier of these units.

Advantages of *TOCCO* Vertical MG Sets

The large TOCCO vertical type motor generator set has numerous advantages over conventional horizontal type sets. Vertical construction permits the use of very large bearings and also minimizes the hazard of major damage to the set in the unlikely event of a bearing failure. Longer bearing life is achieved due to lower pressure and uniform loading of the bearings. Maintenance is greatly simplified because the rotor can be removed vertically with a simple hoist. Anti-vibration mountings between the base and the MG rotor-stator assembly practically eliminate vibration. No special foundations are needed. Lastly, TOCCO's vertical design cuts necessary floor space to less than one-half the area required by horizontal motor-generator sets.

Only Time-Tested Vertical MG Sets—*TOCCO*

There are over a thousand TOCCO vertical MG sets in actual service TODAY—more than all competitive horizontal makes combined. Write us for descriptive bulletin giving full details on the advantages and construction details of TOCCO Vertical MG Sets.

TOCCO Vertical MG sets are available in sizes up to 350 KW and frequencies from 1000 to 10,000 c.p.s.

THE OHIO CRANKSHAFT COMPANY

TOCCO

NEW FREE BULLETIN

Mail Coupon Today

THE OHIO CRANKSHAFT CO.
Dept. T-8, Cleveland 5, Ohio

Please send copy of "TOCCO High Frequency Motor-Generator Sets."

Name_____

Position_____

Company_____

Address_____

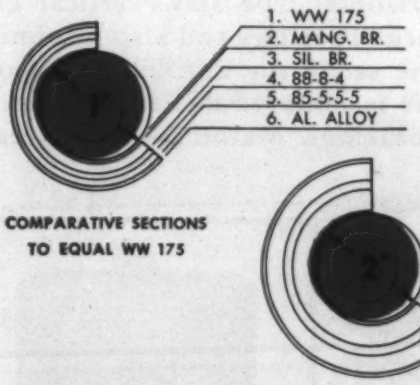
City_____ Zone____ State_____

• For more information, turn to Reader Service Card, Circle No. 469

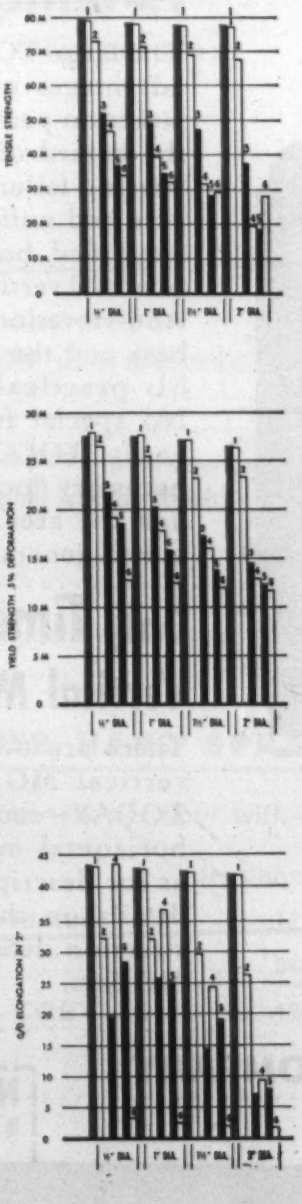
DESIGN FOR

WW 175 ALUMINUM BRONZE

and put the SURPLUS in your pocket



COMPARATIVE SECTIONS TO EQUAL WW 175



The two diagrams above show relative sections cast nonferrous alloys required to *equal* the tensile strength of 1″ and 2″ dia. WW 175 Aluminum Bronze. Note how tensile strengths fall off as sections increase—except when you design with WW 175, the *constant* alloy! The comparison becomes even more dramatic when you study the bar charts showing tensile and yield strengths and elongation. Regardless of section required, WW 175 retains these mechanical values with only a minor decrease.

What does this mean? You can design smaller sections requiring less metal (a saving even when WW 175 is compared to many cheaper alloys), you reduce the mass, you save weight—so you cut the cost of your product while improving its performance. Don't forget, too, that WW 175 at .274 per cu. in. weighs substantially less than most competitive bronze alloys.

Want to know more about the big family of WW Aluminum Bronze Alloys? Our new catalog gives full details, specifications, properties, applications of 16 types, comparative specs, machining recommendations and information on our foundry and production facilities. Write for No. 15,100-1 and name of our representative in your area.

WW ALLOYS, INC.

11695 CLOVERDALE AVE.
DETROIT 4, MICHIGAN

Division of Fansteel Metallurgical Corporation

OTHER NEW MATERIALS PRODUCTS

corrosive environments, Phenoline 305 resists splash, spillage and fumes of most acids, alkalies and solvents. It can be applied over sandblasted or wirebrushed steel, wood or concrete.

8. Conductive organic coating

An electrically conductive organic coating that has excellent chemical resistance is available from *Alfred Hague & Co., Inc.*, 227 34th St., Brooklyn 32, N. Y. Called Rubalt No. 538-L Black, it is applied by brush, spray or roller. Because it adheres to plastics, ceramics, rubber and similar surfaces, it provides an electrically conductive path for surfaces that would otherwise be electrically nonconducting. The coating resists acids, alkalies and other chemicals, oils and grease.

For one coat, the conductance between two points 1 in. apart ranges from 1 x 10^{-4} to 9 x 10^{-4} mhos. Conductance can be reduced by mixing clear vehicle into the black.

The coating can be used in printed circuitry and can be applied to thin dielectric sheets and films used in condensers, such as cellophane, polyethylene and Mylar. It is also used as an electrostatic shield in cathode ray tubes and on the inside of plastics electronic housings. On rigid or flexible surfaces such as power belts it serves as a static eliminator.

9. Lacquer for metals

A multiple purpose lacquer for metals has been developed by *Fidelity Chemical Products Corp.*, 470-474 Frelinghuysen Ave., Newark 5, N. J. Designated Clear Universal Lacquer No. 100, it is applied by dip or spray. It is claimed to eliminate the need for switching from one lacquer to another when a different metal is to be finished.

Water white in color, it has good color retention and adhesion. It dries out of dust in 5 to 10 min and dries hard in 1 hr. The lacquer film resists perspiration, corrosion and stain spotting.

(continued on p 162)

For more information, turn to Reader Service Card, Circle No. 505

compare with the standard ...in high speed steels the standard's REX

Ever since grandad's day, Crucible's REX® high speed steel has been *the standard by which all other high speed steels are compared.* And now the quality and uniformity of REX are even *better*, thanks to improved manufacturing techniques at Crucible.

Don't take our word for it. Prove for yourself how REX leads in structure, uniformity, response to heat treatment, and fine tool performance.

Ask for REX at your nearby Crucible warehouse — or order it through prompt mill shipments. And, for a list of available data on all Crucible special purpose steels, write now for a free copy of the "Crucible Publication Catalog". *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

For more information, turn to Reader Service Card, Circle No. 373

Costly new equipment is not always the sole answer to production cost problems. Often the wrong raw material may completely nullify expected savings from heavy capital investments in modern machinery.

Consider the case of one manufacturer who installed expensive new forming equipment but was unable to up production to the expected level. Material being formed was cold rolled strip 4" x .060", AISI 1050 steel processed to standard gauge tolerances (.0567" to .0632").

When **CMP** Precision Cold Rolled Strip Steel ordered to a 60% gauge restriction (.0587" to .0613") was furnished, production immediately moved up to the rated capacity of the machines and has remained there.

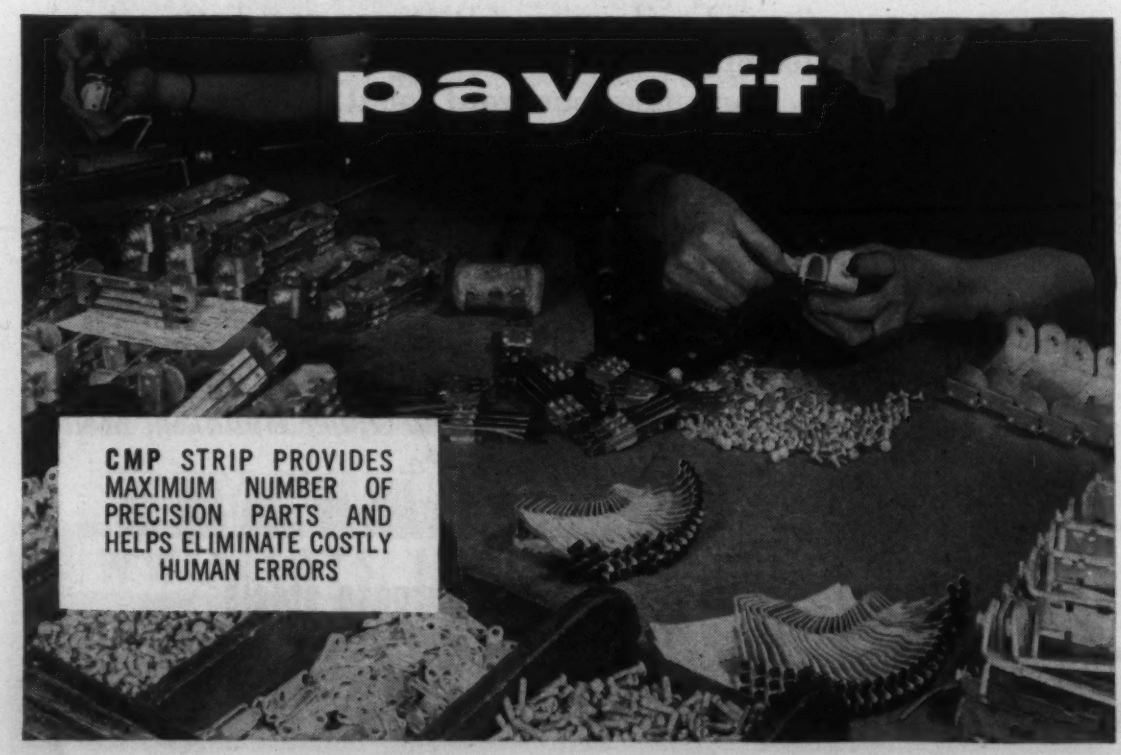
In addition to increased production, because of the minimization of down time, an incidental and important benefit was the increase in yield per **CMP** ton processed because rejections and out of tolerance parts were eliminated.

Careful consideration of **CMP** Restricted Specification Cold Rolled Strip Steel alternatives on the same careful basis given to your equipment investment, may point the way to similar, or larger pay-offs.

Why not check the possibilities today?

CMP Products—low carbon, electro zinc coated, high carbon, tempered spring steel, stainless and alloy.

THE COLD METAL PRODUCTS CO.
GENERAL OFFICES: YOUNGSTOWN 1, OHIO
PLANTS: YOUNGSTOWN, OHIO AND INDIANAPOLIS, IND.
SALES OFFICES: NEW YORK CLEVELAND DETROIT INDIANAPOLIS CHICAGO LOS ANGELES SAN FRANCISCO



For more information, turn to Reader Service Card, Circle No. 386

OTHER NEW MATERIALS PRODUCTS

10. Chrome sealers

A group of protective chrome sealer type films have been announced by *Conversion Chemical Corp.*, Rockville, Conn. They are designed to provide protection for such common nonferrous metals as copper, zinc, brass, cadmium and aluminum against tarnish, stains, fingerprints and corrosion under a paint film. The finishes are applied in simple, short, dipping operations and are claimed to be superior to oxide or phosphate films.

11. Antirust compound

A new antirust compound protects parts so that they can be stored indoors for 30 days or more under normal conditions. Called NoRuSol, the water soluble compound is available from *International Chemical Co.*, 2628 N. Mascher St., Philadelphia 33. It can be applied by spraying or dipping.

Parts coated with NoRuSol are claimed to have shown no rust after 400 hr exposure in a humidity cabinet at 100 F and a relative humidity of 100%.

Shielding Material for Atomic Reactors

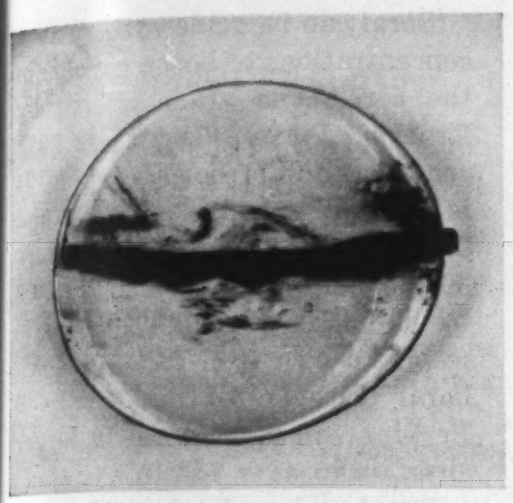
A neutron shielding material used by atomic energy installations and atomic power plants is now available from two manufacturers. Called boral, it is made by *Aluminum Co. of America*, 1501 Alcoa Bldg., Pittsburgh 19, and by *Brooks & Perkins, Inc.*, 1950 W. Fort St., Detroit 16.

Boral was developed by the Atomic Energy Commission at Oak Ridge, Tenn., and produced there in limited amounts. According to the AEC, plate 0.250 in. thick has an effective shielding power equal to that of a concrete slab 100 times greater in thickness.

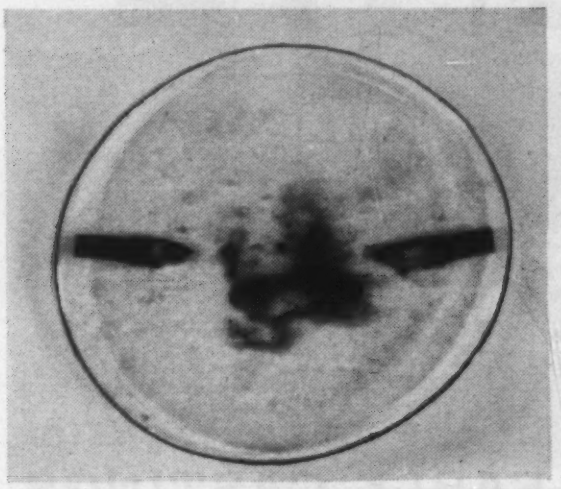
Boral, a name taken from its ingredients, boron carbide (B_4C)

KEL-F® ELASTOMER
IS SHATTERING IDEAS ABOUT RUBBER

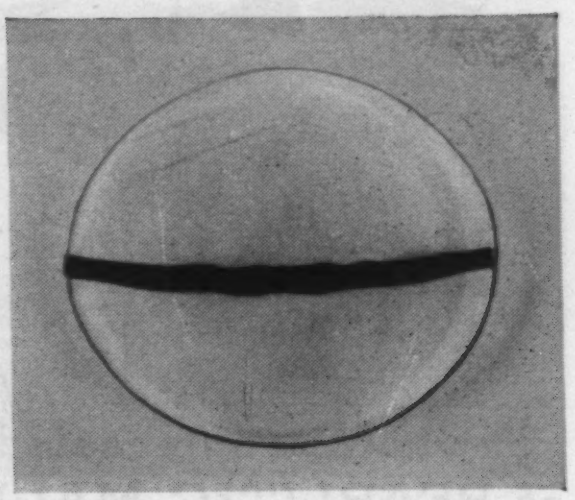
Challenging new fluorocarbon rubber has outstanding... CHEMICAL RESISTANCE... HEAT RESISTANCE



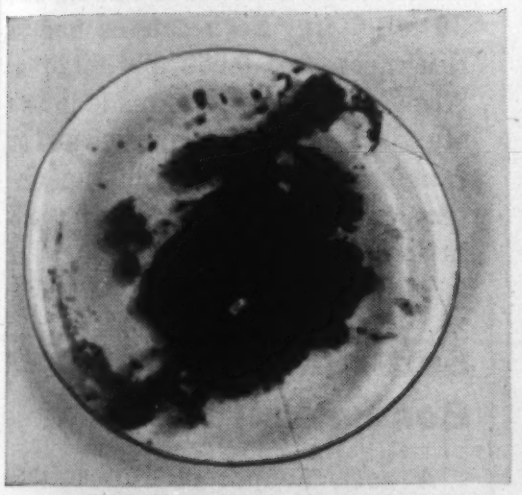
BUNA-N—10 min. immersion in RFNA



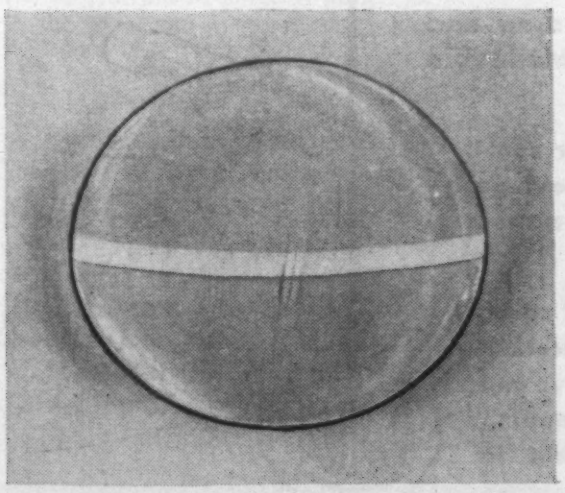
NATURAL RUBBER—10 min. immersion in RFNA



BUTYL—2 hr. immersion in RFNA



GRS—10 min. immersion in RFNA



KEL-F ELASTOMER—one week immersion in RFNA

IMMERSION IN RED FUMING NITRIC ACID for one week has no appreciable effect on the physical properties of KEL-F Elastomer. Extensibility and hardness remain virtually unchanged. Other available rubbers disintegrate within a matter of minutes.

When severe operating conditions demand a chemical rubber that *must* stand up under high temperatures and corrosive atmospheres—KEL-F Elastomer is the answer.

Developed by Kellogg, KEL-F fluorocarbon rubber combines superior elastomeric properties with excellent chemical resistance and thermal stability. Other outstanding advantages include: high chemical resistance to solvents, fuels and lubricants . . . low moisture absorption . . . non-flammability . . . excellent resistance to weathering and microorganisms.

This *unique* combination of properties makes KEL-F Elastomer useful in applications such as heat-and-chemical-resistant hose, tubing, diaphragms, gaskets, seals, tank linings, corrosion-resistant clothing, paints, flame-resistant coatings, and electrical insulation.

If your work requires an elastomer with outstanding resistance to heat and corrosion, look into KEL-F Elastomer. Our technical staff is prepared to assist designers, engineers, and production men in adapting KEL-F Elastomer to their individual needs. Kellogg supplies KEL-F Elastomer in the gum form only. Names of qualified fabricators of specific end uses of KEL-F Elastomer are available on request.

HOT OFF THE PRESS! *Our newly published booklet, "KEL-F Elastomer," is yours for the asking. Just fill out and mail coupon below for your free copy.*

®KEL-F is the registered trademark of The M. W. Kellogg Company for its fluorocarbon products.

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Send me a copy of your new booklet, "KEL-F ELASTOMER."

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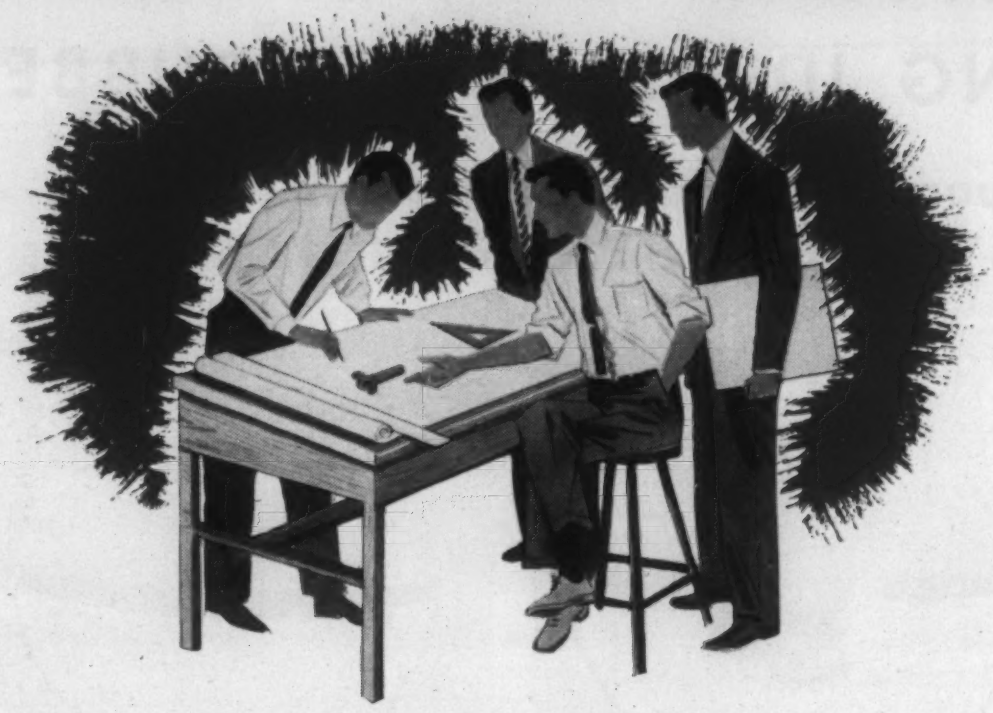
THIS IS FOR MEN...



. . . who are interested in the advantages of of PEARLITIC MALLEABLE CASTINGS

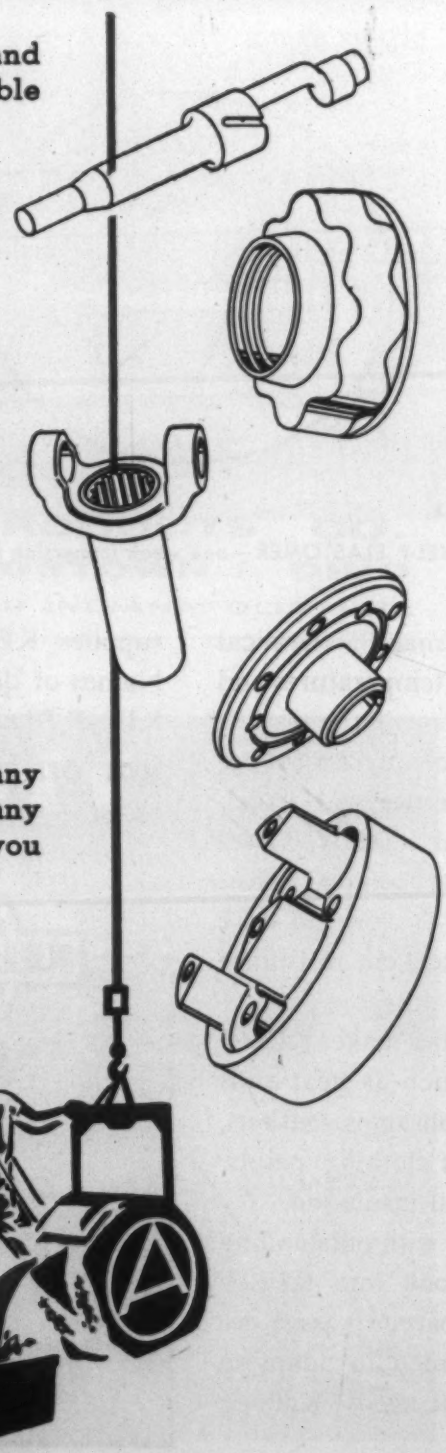
● **You can slash production, machining and assembly costs with Albion Pearlitic Malleable Iron Castings. And, here's why:—**

. . . Albion's pearlitic malleable irons offer complete freedom of design for greater savings in machining time, the elimination of excess metal and lower finished part cost.

. . . Albion's pearlitic malleable irons afford unusually fine wear resistance with excellent bearing properties. Maximum rigidity and prolonged fatigue life offers outstanding endurance. Yield strength comparable to steel forgings.

. . . Albion's pearlitic malleable irons have a fine, uniform grain structure that machines easily and accurately with exceptional mirror-smooth finishing qualities. Extremely adaptable to localized hardening for specific needs.

Contact the Albion Malleable Iron Company now . . . they'll be glad to show you how many ways Albion's pearlitic irons can save you time, tools and dollars.



Remember . . . Albion's Research and Development Laboratory facilities and competent engineering staff are ready to help you design better products that can be made at lower cost.

ALBION MALLEABLE IRON CO.

Albion, Michigan

For more information, turn to Reader Service Card, Circle No. 551

OTHER NEW MATERIALS PRODUCTS

and aluminum, consists of a core of boride carbide uniformly dispersed in aluminum, clad on both sides with commercially pure aluminum.

Boral can be made with various concentrations of boron carbide in the core. The grade offered by Brooks & Perkins, Inc., has a 35% concentration of boron carbide. It is made in rolled plate 0.250 and 0.125 in. thick. Standard sizes are 30 x 96 in., 30 x 48 in., 15 x 96 in. and 15 x 48 in. Approximate weight per sq ft of 0.250-in. thick boral plate is 3.4 lb. Brooks & Perkins will make boral in larger sizes up to 48 x 144 in.

Boral is made by Alcoa in standard sizes of 48 x 120 in. and 36 x 96 in. Both can be had in thicknesses of 0.250 and 0.125 in. Alcoa's boral plate is made in two standard tempers, annealed and as fabricated. The "O" or annealed temper is recommended for applications involving forming.

Soft Nonporous Rubber Bonds Well to Metal

A soft, nonporous rubber that can be securely bonded to metal has been developed by *Roth Rubber Co.*, 1860 S. 54th Ave., Chicago 50. Called compound RRD-992, the rubber has a softness characteristic of 5 durometer and can be used at temperatures up to 200 F. It is a reasonably good electrical insulator.

The rubber, which is not a

***Good bond** to metal is obtained with new soft, nonporous rubber.*

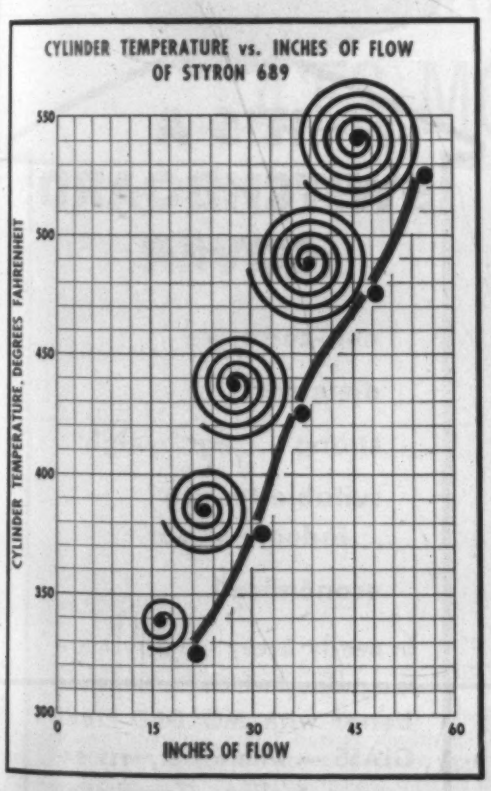
PLASTIATRICS . . . *No. 7 of a Series*

DOW

DEVELOPMENT OF FREE-FLOW STYRON 689 ASSURES FASTER INJECTION MOLDING

New formulation proved excellent for molding thin sections, deep draws, large area parts

For years the plastics industry has been demanding polystyrene materials that would allow faster injection molding. Through Plastiatrics, Dow's clinical approach to healthy plastics application, Styron® 689 was developed to meet this growing demand. An easier flowing material, Styron 689 also has much faster setup time than other materials available. Its uniform flow characteristics (see chart) are especially important in multiple cavity molds with very thin sections and



deep draws. It produces molded parts of uniform physical strength. Its clarity, brilliant sparkle and excellent colorability allow a wide range of transparent, translucent and opaque colors. What's more, Styron 689 is ideal for high speed automatic molding and for large area parts.

Shown here is Styron 689 being tested for uniformity of flow in a standard polystyrene spiral mold at the Dow laboratories. Tests like this result in scientific prediction of performance in the fabrication of finished products.

No. 8 granulation available in Styron 689

A revolutionary granulation of polystyrene material is being offered for the first time in Styron 689. Pellets of No. 8 granulation are 0.080″ diameter by 0.080″ without external lubricant. It offers faster heat absorption in the heating cylinder—5% to 20% greater lb. per hr. throughout. Reduces silver streaking and eliminates fines. Means reliable volumetric and weigh feeding.

Complete technical literature offered

Detailed technical information is available on molding, extrusion, machining, coloring and finishing with Styron 689. Whatever your problem, you may consult Dow with full assurance of prompt, confidential help and advice. Write, on your letterhead, to THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Sales Department PL 434H.

America's first family of better polystyrene formulations

STYRON 666 is the most widely used general-purpose formulation. It has excellent balance of physical properties and moldability.

STYRON 665 is similar to Styron 666 but is especially tailored for extrusion.

STYRON 688 is an easy flow formulation developed for injection molding.

STYRON 689 is a newer and easier flowing formulation than Styron 688. The brilliant sparkle and lack of haze add to the attractiveness of crystal parts molded with this material.

STYRON 683 is a heat-resistant grade of polystyrene.

STYRON 700 has the highest heat resistance of any commercial polystyrene.

STYRON 777 is a medium-impact material used where the high elongation and impact strength of 475 is not required.

STYRON 475 is a high-impact polystyrene formulation. It has three to five times greater impact strength and ten times the elongation of general-purpose polystyrene.

STYRON 429 is a high-impact polystyrene especially suited for extrusion of parts which require better surface gloss and texture.

STYRON 440 is a heat-resistant impact formulation. It was developed for applications such as radio cabinets where the combination of high impact and heat resistance is required.

STYRON 480 has an extra-high-impact strength. In addition to toughness it has good heat resistance and surface gloss.

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OTHER NEW MATERIALS PRODUCTS

sponge, can be used to absorb vibration, to dampen sound, or as an airtight or watertight gasket. It is available in sheets or strips up to 1 in. thick. Roth Rubber Co. will also mold or bond it to metal or other odd shapes.

Current applications for RRD-992 include a tiny mounting ring for an electronic hearing aid and a watertight seal for a metal sieve conveyor belt.

Two Urethane Foams Insulate, Reinforce

Two thermosetting, self-curing urethane foams for insulating and reinforcing voids between structural members are available from *Adhesives & Coatings Div., Minnesota Mining & Mfg. Co.*, 423 Piquette Ave., Detroit 2. The two foams can be used to fill cavities where light weight, structural strength, stiffening, vibration dampening and durability are desired.

Designated Scotchfoam Brand Expansible Compound Type A and Type 1, the compounds are two-part liquid formulations. When mixed with a catalyst under proper conditions, they can be foamed in place to produce a rigid cellular material that will not break loose, settle or sag. They may be poured or sprayed.

Design advantages

Both of these low density urethane foams have good thermal stability and good thermal, acoustical and electrical insulating properties. They adhere to most metals, plastic wood, glass and ceramics. They are insoluble in water and most petroleum products. Chemical resistance is considered generally good.

Design advantages for the two foams include: 1) low weight factor, 2) adhesion to many types of surfaces without the need for supplementary adhesives or mechanical fasteners, 3) curing without heating, 4) freedom from

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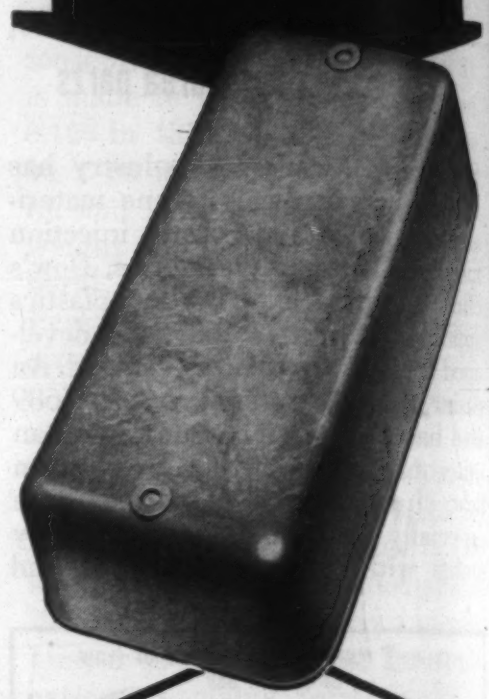

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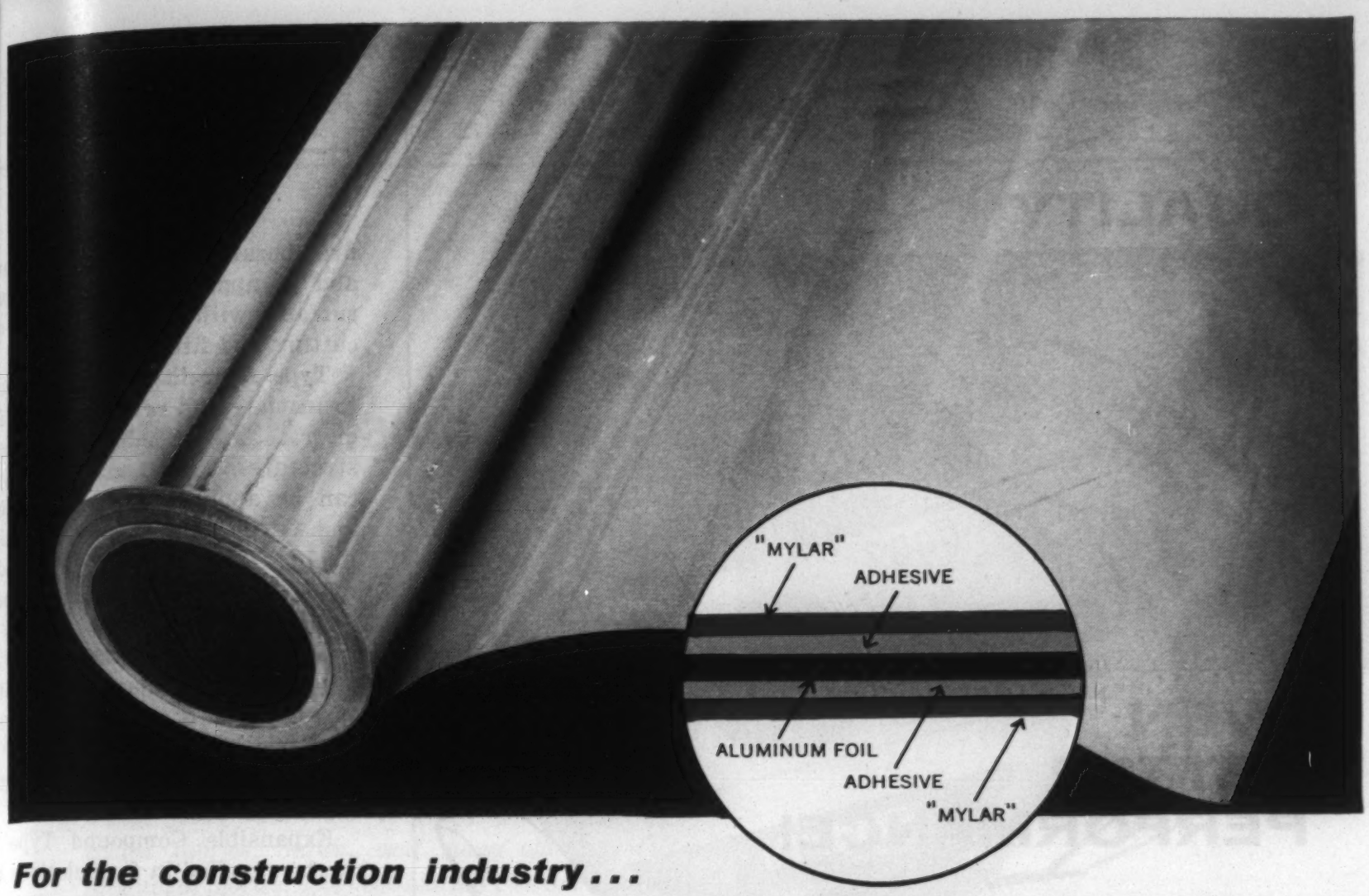

For the construction industry...

A NEW BARRIER ARMORED WITH "MYLAR" REDUCES MOISTURE PERMEABILITY TO ZERO!

Food Fair Company's new frozen-food warehouse in Linden, N. J., uses vapor barrier made of Du Pont "Mylar" and foil. The barrier is easily applied and sealed tightly with pressure-sensitive tape of the same material. Men shown walking on the vapor barrier illustrate the extra toughness and abrasion resistance of this lamination with "Mylar".

Thanks to a new material made of Du Pont "Mylar"* polyester film and aluminum foil, industrial constructors have a completely new moisture-barrier material for more effective control of humidity. Already, this new material is being used in warehouses for frozen-food storage, special rooms for the operation of extra-sensitive electronic equipment and storage facilities for military equipment.

This new laminate with "Mylar" is strong yet light in weight – there's no need for extra support frequently used for heavier moisture barriers. Since this flexible material comes in roll form, it's much easier to install than rigid barriers. When slit into tape widths with a pressure-sensitive adhesive, this same laminate provides an effective seal to join the sheet together. Most important, this laminate of "Mylar" and foil provides *zero permeability* to moisture vapor!

Here is another example of how Du Pont "Mylar", used alone or in combination with other materials, is improving old products and helping create new ones. For more information on properties, applications and types of "Mylar" available, send in the coupon below. Be sure to indicate specific application you have in mind.

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***MYLAR** is Du Pont's registered trademark for its brand of polyester film.*

In Canada, "Mylar" is sold by the Du Pont Company of Canada Limited, Films Div., P. O. Box 660, Montreal, Quebec.

DU PONT **MYLAR**® POLYESTER FILM

E. I. du Pont de Nemours & Co. (Inc.)
Film Dept., Room MM-8, Nemours Bldg., Wilmington 98, Delaware

☐ Please send information on properties, applications and types of "Mylar" polyester film available (MB-4).

☐ Please send information on moisture-barrier material made with "Mylar".

APPLICATION_____

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fire hazard during application, and 5) applicability to irregular surfaces without the necessity of cutting and fitting operations.

Type A urethane foam is used to insulate and reinforce voids in aircraft tail assemblies and other structures. Type 1 urethane foam can be applied between exterior and interior floor panels on railroad passenger cars to provide sound deadening and insulation.

Foam characteristics

Expansible Compound Type A produces a foam having a density of 4 lb per cu ft, a tensile strength of 20 psi, a flexural strength of 4 psi and a dry compressive strength of 14 psi.

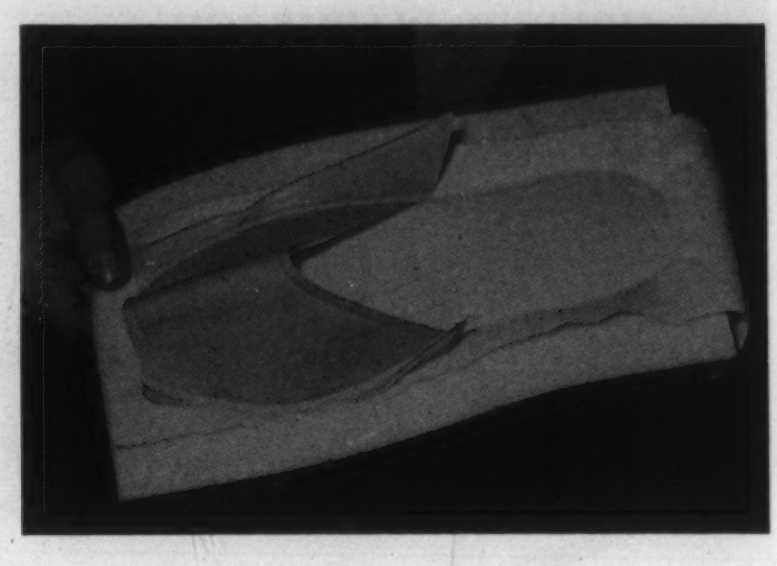
Expansible Compound Type 1 can be supplied in formulations to produce materials ranging from a resilient foam of 2 lb per cu ft density to a rigid foam of 20 lb per cu ft density. Stress required to produce a 50% deflection in a 2-lb per cu ft foam is 12 psi; for a 20-lb per cu ft foam the stress is 750 psi. Maximum surface temperature recommended for continuous use is 212 F and for limited use is 250 F.

Glass-Resin Patches Repair Metal Tanks

Repairs to metal tanks, pipes and conduit without welding are possible with glass cloth patches and an epoxy material called Sonite. According to *Smooth-On Mfg. Co.*, Jersey City 4, N. J., patches have tested up to 1000 psi without failure. Corroded areas, split seams and breaks can be repaired in vessels handling gasoline, oils, acids, alkalies or powdered material.

Patches are applied as follows: 1) the metal area is cleaned and dried, 2) a primer furnished with the repair kit is applied and allowed to become tacky-hard, 3) a glass cloth patch is pressed into the prime coat, and 4) the Sonite epoxy material is brushed over

One-step manufacturing with heat-sealed vinyl foam

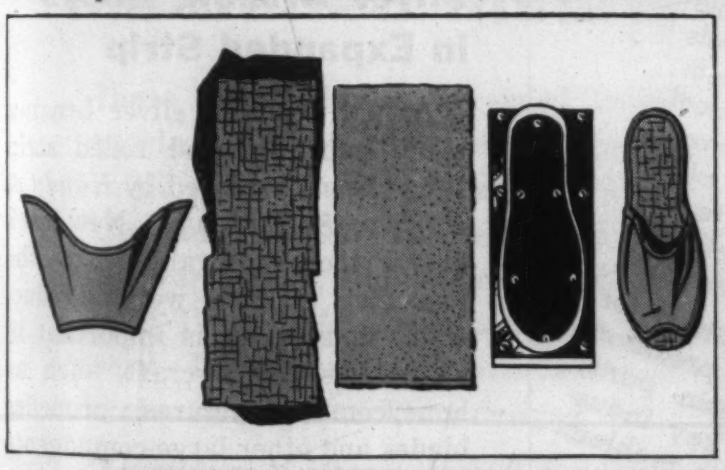


■ *For a wide range of products, you can combine virtually all manufacturing operations into a single processing step by using vinyl foam and new heat-sealing methods.*

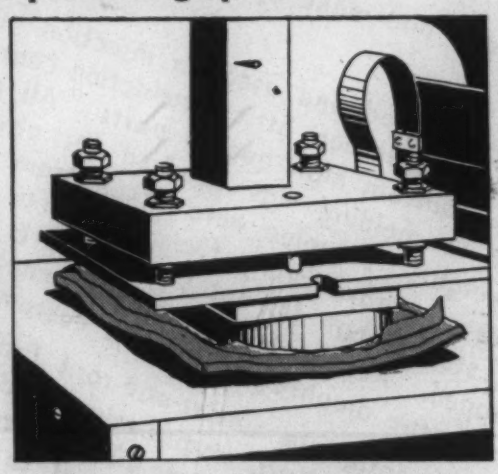
Vinyl foam heat-seals to itself, to vinyl film, to coated fabrics, Saran, and many other synthetic or natural fabrics. The heat-sealing—in one operation—can form, mold, and permanently bond together several component parts. You can eliminate production steps such as shaping, sewing, and gluing . . . and you can use a "tear-seal" die to eliminate preliminary cutting and the final trim finishing. Vinyl foam can give you:

- *Built-in cushioning*
- *Wear and abrasion resistance*
- *Unlimited choice of colors*
- *Resistance to soaps, oils, acids, alkalis*
- *Fire resistance*

Three-piece lounging slipper is fabricated in one processing operation



Start with vinyl film top, vinyl foam insole, embossed vinyl film outersole.



Shape, mold, and permanently bond component parts in a "tear-seal" die with a single heat-sealing operation.

The "tear-seal" die allows the slipper to be removed by simple hand-tearing.

MONSANTO

Where Creative Chemistry Works Wonders for You

You can also fabricate vinyl foam by die-cutting, splitting, skiving, molding, stitching, hot-wire shaping or forming. Monsanto manufactures plasticizers and vinyl resins for vinyl foam . . . but does not produce or distribute the finished formulations. For sources of vinyl foam sheets or slabs, write MONSANTO CHEMICAL COMPANY, Organic Chemicals Division, Department ID-4 St. Louis 1, Mo.

Saran: Reg. trademark of Dow Chemical Co.

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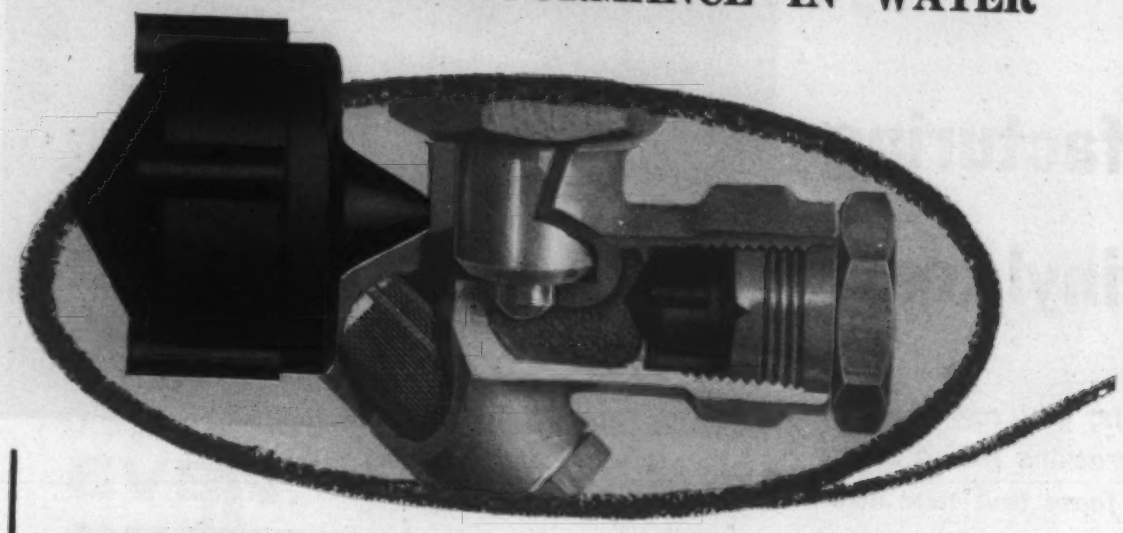
THE SHAPE OF THINGS IN MOLDED RUBBER

MOLDED DIAPHRAGM GIVES TOP PERFORMANCE IN WATER



APPLICATION:
The diaphragm shown here is the heart of a precision water flow control device for use in various appliances where automatic water flow control is necessary. It automatically maintains one set water flow regardless of inlet pressures or temperatures. This new unusual device is manufactured by a company famous for supplying brass and iron products for the water, gas and plumbing industries.

PROBLEM:
This diaphragm, less than 1" in diameter, must withstand pressures from 10 to 150 lbs. psi. and guaranty water delivery within 10% ± of the valve rate capacity. The diaphragm must also flex in temperatures ranging from 50°F. to 150°F. Mold it and make it work!

SOLUTION:
Acushnet engineers designed and used an injection mold to obtain the necessary precision. Strict production controls were instituted to maintain high quality parts. All neoprene stock prior to molding was checked for physical properties and weight. Samples were taken from every heat for flow tests approximating five days. For extra quality control, stocks that did not produce parts to the spec were scrapped. Acushnet now molds a complete line of precision neoprene diaphragms for this customer.

Acushnet offers complete under-one-roof facilities for the accurate compounding, engineering and precision molding of rubber, silicone and silicone resin parts. Apco technical representatives located in key industrial areas are ready to help you with your problem.

Send for Acushnet "Rubber Data Handbook."

What's Your Shape?

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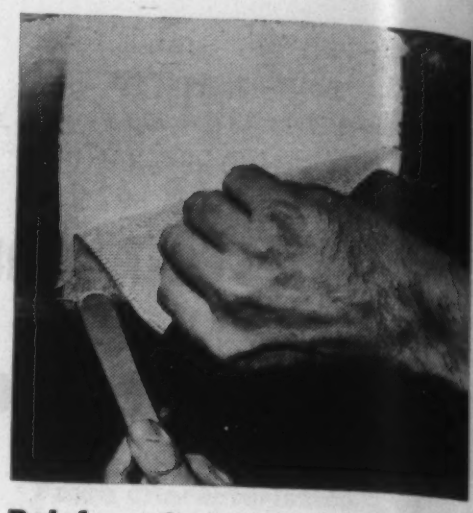
OTHER NEW MATERIALS PRODUCTS



***Reinforced plastics** patches repair tanks, pipes and conduits.*

the cloth, including the edges. Two or more layers of glass cloth and resin are used. The patch hardens in 18 hr.

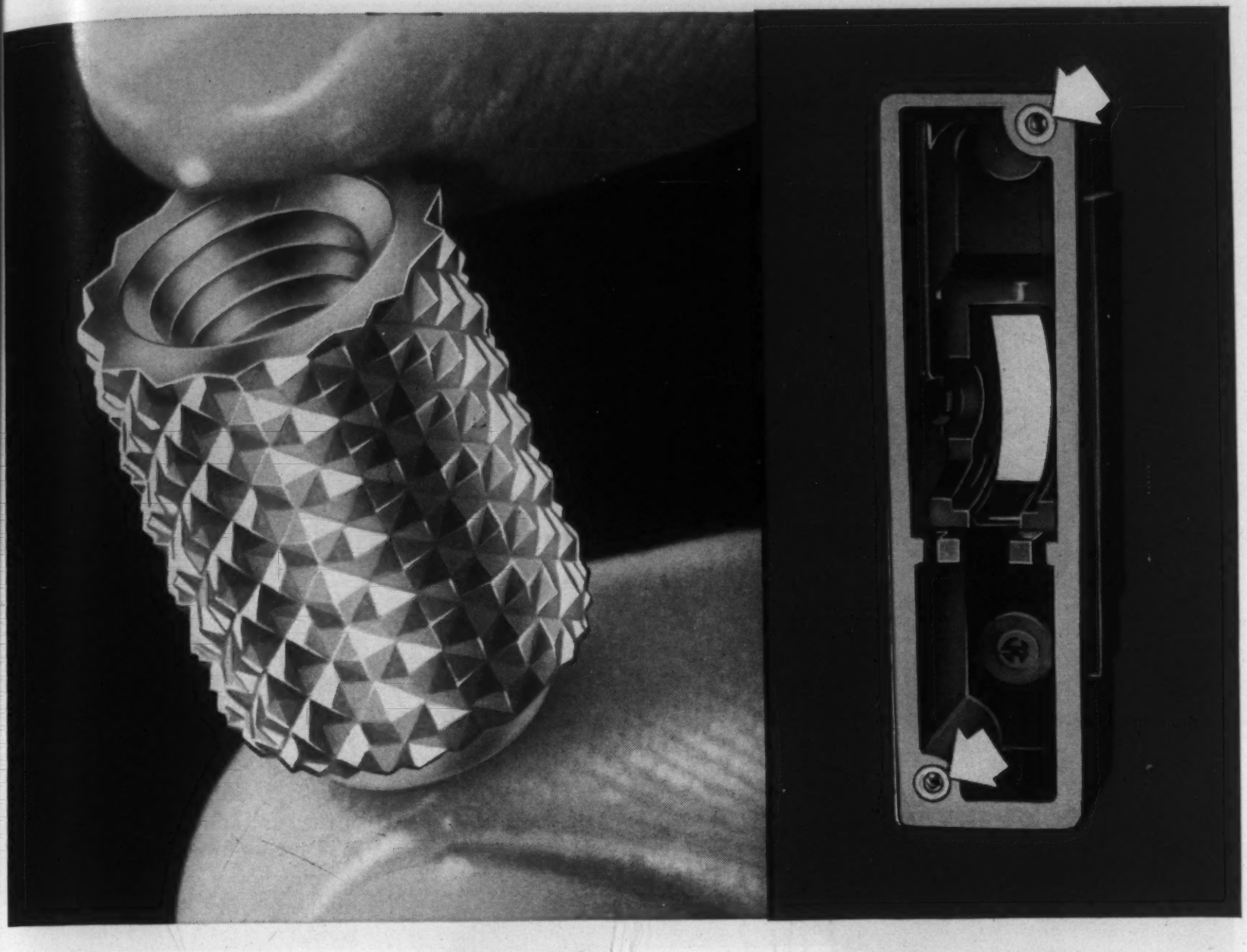
Sonite has chemical stability and good adhesion to metals. It is oil and waterproof, resists acids and alkalies and will withstand temperatures to 200 F. It is available in white and aluminum, Sonite P-2 and P-5, respectively.

Silver Brazing Alloys in Expanded Strip

A new form of silver brazing alloy—expanded and rolled strip—has been developed by *Handy & Harman*, 82 Fulton St., New York 38. Principal advantage of the expanded strip is weight reduction. This factor is important in assemblies for aircraft, such as honeycomb structures, propeller blades and other large components usually joined by brazing.

An expanded strip may weigh less than one third as much as a solid strip of the same cross section thickness. To match the weight of 0.003-in. expanded strip, a solid strip would have to be well under 0.001 in. in thickness. This is seldom practical because such thin foils are too fragile to handle conveniently.

Because of the high fluidity of molten silver alloys, the expanded strip will flow and wet the joint



Versatile Aluminum . . . Natural Choice for Machined Inserts in Plastic Molded Parts

These little fellows—threaded inserts for molded plastic parts—are produced by the millions at Yardley Precision Products Company, Yardley, Pa. Because of its amazing versatility, they fabricate them from 2011-T3 *Reynolds Aluminum screw machine stock.* It helps make inserts better, lowers costs, simplifies molding designs.

Aluminum is strong. It permits ample wall thickness without bulk . . . yet insures sufficient strength to withstand molding pressure without rupturing the insert. And aluminum enables Yardley to produce inserts to precision standards with clean threads and coarse knurls.

Lightweight aluminum does all this while lowering costs. It gives three times as much metal per pound as brass or steel—permits high-speed machining—provides lowest total cost for material and machining.

For more information call the nearest Reynolds Office or Distributor listed under "Aluminum" in classified telephone directories. Ask for brochures, "Reynolds Aluminum Screw Machine Stock" and "Aluminum Machining Data, Speeds and Feeds." *Reynolds Metals Company, P.O. Box 1800-HM, Louisville 1, Kentucky.*

The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

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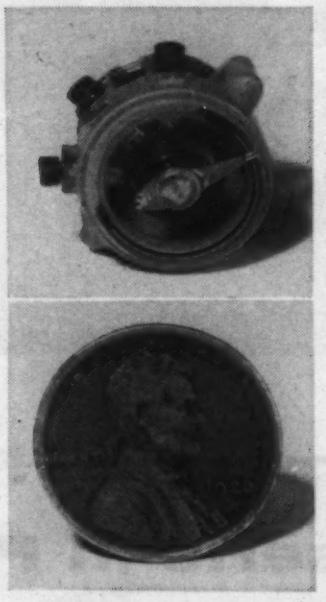
HOW 3-D MICRO-VISION HELPS FAIRCHILD

manufacture world's tiniest production-run potentiometer



In a case less than ½" in diameter, 35 sub-miniature parts are precision-assembled; hair-thin springs are welded into fine slots. This tiny unit, designed and developed by the Guided Missiles Division of Hughes Aircraft Company, is a sensing and controlling element for aircraft and missiles; critical tests must assure highest mechanical and electrical efficiency.

Fairchild Camera and Instrument Corporation attributes the efficient mass-production of this unit to the use of Bausch & Lomb Stereomicroscopes—in assembly, inspection, and quality control. "Operators have both hands free and use both eyes to obtain normal, three-dimensional vision magnified to the required power—with high efficiency and operator comfort."

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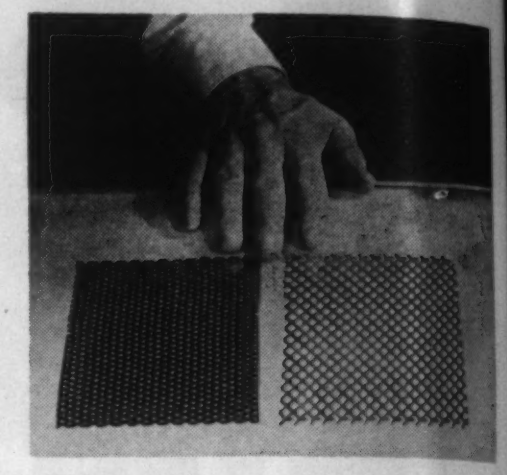
OTHER NEW MATERIALS PRODUCTS



***Weight reduction** is advantage of expanded brazing strip.*

faces uniformly despite the interstices in the grid pattern. The supplier claims this is true not only for continuous joint faces, but also for honeycomb structures. Therefore, maximum joint strength and uniform bonding will be obtained regardless of the alignment between the grid of the alloy and the edges of the honeycomb.

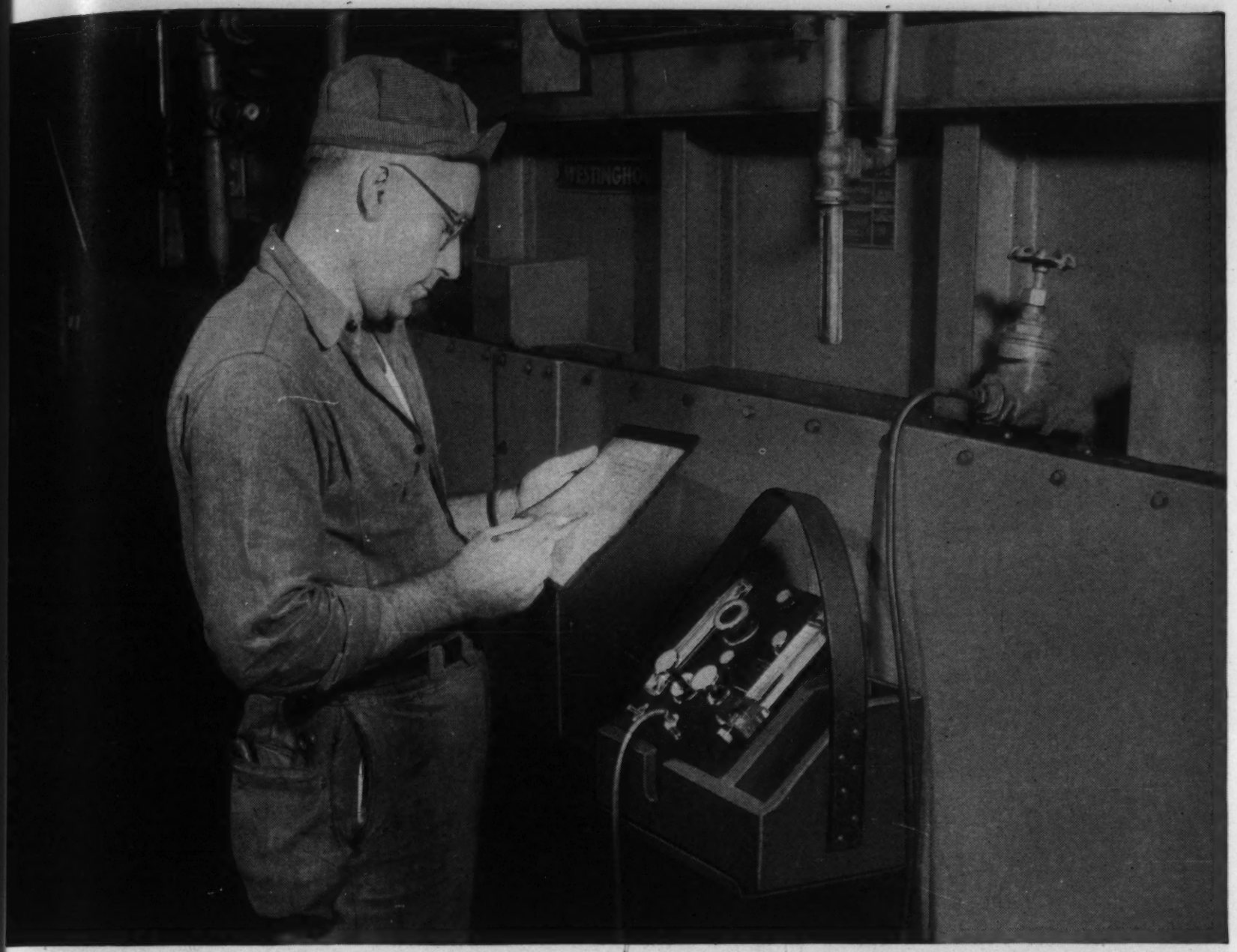
The expanded silver alloy is made by expanding conventional solid strip and then rolling the resulting grid down to the specified uniform thickness. The weight of expanded strip is governed by the degree of expansion and by the final thickness after rolling. Expanded strips up to 12 in. wide in precision thicknesses down to 0.003 in. are available. All of the Easy-Flo and other brazing alloys normally supplied by Handy & Harman in strip form are made in the expanded form.

Tapes—Electrical, Printable, Nonstick

The following roundup on tapes covers a non-stick pressure sensitive Teflon tape, epoxy resin-impregnated electrical tapes, an exceptionally thin Teflon tape for electrical insulation, and two new printable tapes.

1. Teflon nonstick tape

A 0.013-in. pressure sensitive Teflon tape has a useful tempera-



The Most Valuable Information for the Heat Treater...

"The most valuable information for the heat treater... is accurate, reliable data to show him how to adjust furnace atmosphere."

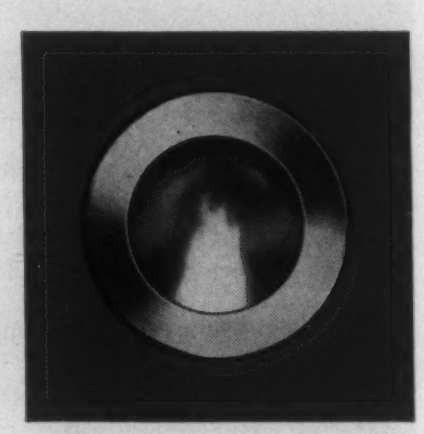
That is one of the most significant quotes from papers presented at the recent National Metal Congress. And the practical answer on control of furnace atmospheres is to determine carbon potential by reading dewpoints in each furnace zone with an Alnor Dewpointer.

With the Dewpointer You Can:

1. Read Each Furnace Zone. With the portable, self-contained Dewpointer, you can readily check each zone in the furnace...instantly detect restricted flow of atmosphere, leaky furnace seals or transient moisture and air from the quench tank, and air carried into the furnace with the charge.

2. Get Accurate Data. Only the Dewpointer gives you controlled testing conditions...indications take place in enclosed chamber. Dew or fog is suspended in air as sunbeams—not on a polished surface. This gives you the greater accuracy, faster readings required for critical atmosphere control.

3. Fast, Easy Reading. In one relatively inexpensive instrument, the Dewpointer brings you simple, direct operation that enables any shop man to get readings with laboratory accuracy—every time. It is wholly self-contained, operates on either AC or enclosed battery.



Eliminate Guesswork

You actually see the dew or fog suspended in a test chamber—no guessing as to when fog starts to form on polished surface. Find out why the Dewpointer is so widely used for accurate atmosphere control. Send for your copy of new illustrated Dewpointer Bulletin.

Alnor

ILLINOIS TESTING LABORATORIES INC.

Room 522, 420 N. La Salle Street • Chicago 10, Illinois

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ture range of —100 to 400 F. Called Temp-R-Tape TH, it is made by *Connecticut Hard Rubber Co.*, 407 East St., New Haven 9, Conn. The tape is recommended for use on gussets, fins, forming dies and heat sealing bars on packaging machines, as well as on labeling machines, folding machines, printing presses and food processing machinery.

The tape is tasteless, odorless and noncontaminating. It adheres well to metals, plastics, ceramics and most other materials. Adhesion, rated at 50 oz, increases at higher and lower temperatures. The tape can be applied to dry surfaces at any temperature within its range and eliminates the need of dismantling machinery as in the use of sprayed Teflon.

2. Epoxy electrical tape

The electrical advantages of epoxy resin plus the convenience of tape are features of two new resin tapes. Designated Scotchcast Tape X-1035 and Tape X-1045, they have been developed by *Minnesota Mining & Mfg. Co.*, Dept. D6-54, 900 Fauquier St., St. Paul 6, Minn. Both tapes meet Class B electrical insulation performance requirements.

Tape X-1045 is a polyester mat coated to a nominal thickness of 14 mils. According to 3M, its 45% elongation may be used to produce shrinkage on cure. This shrinkage permits a tight build-up of insulation free from voids without use of molds.

Tape X-1035 is a 4-mil glass cloth also coated to 14 mils. Both tapes have a dielectric strength of 1000 v per mil and a volume resistivity of 10^{12} ohms at 96% R.H. A complete cure requires 2 hr at 290 F. Insulation sections have been cured in 3 to 5 min when pressures of 300 to 500 psi were applied and the press was heated to 390 F.

3. Teflon electrical tape

Teflon tape 0.0005 in. thick is available from *Enflo Corp.*, Route 38 at Airport Circle, Pennsauken, N.J. Used in capacitors, trans-

Fabricon Reinforced Plastic Moldings permit GREATER FREEDOM OF DESIGN!

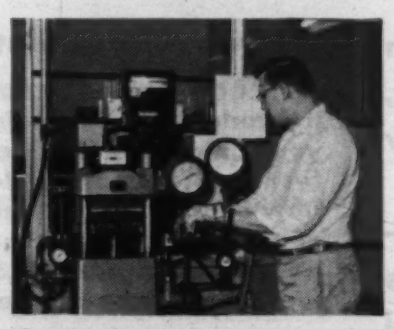
Take a good look at many of today's smart new automobiles and you'll find that an amazing number of parts are now being made of reinforced plastics . . . *custom molded by Fabricon!* Heater housings, seat back panels, bonding strips, garnish moldings, just to name a few. What's more, if you look around, you'll also find that Fabricon reinforced plastic moldings are playing an increasingly important role in the design and manufacture of many other products, too. And for very good reasons!

1. Because the premix compounds are scientifically developed and produced by Fabricon to meet the specific requirements of each individual application.

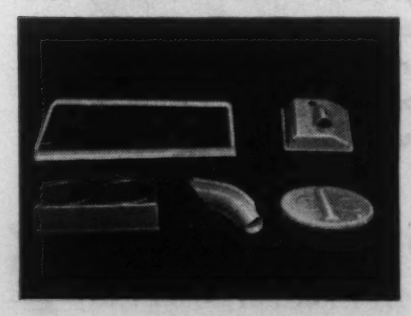
2. Because basic materials selected are processed by Fabricon's special laboratory controlled methods to assure proper distribution of fiber reinforcements throughout each finished molded part.

3. Because the greater uniformity of physical characteristics thus obtained permit the use of Fabricon reinforced plastic moldings on countless applications generally considered impractical or, indeed, impossible just a few short years ago. And . . .

4. Because ease of molding plus *lower tooling costs* permit efficient, economical production of intricate, complex parts. Parts which require no costly secondary or assembly operations . . . which in turn invariably permits greater freedom of design!



Complete facilities for the development of new products and processes for you!



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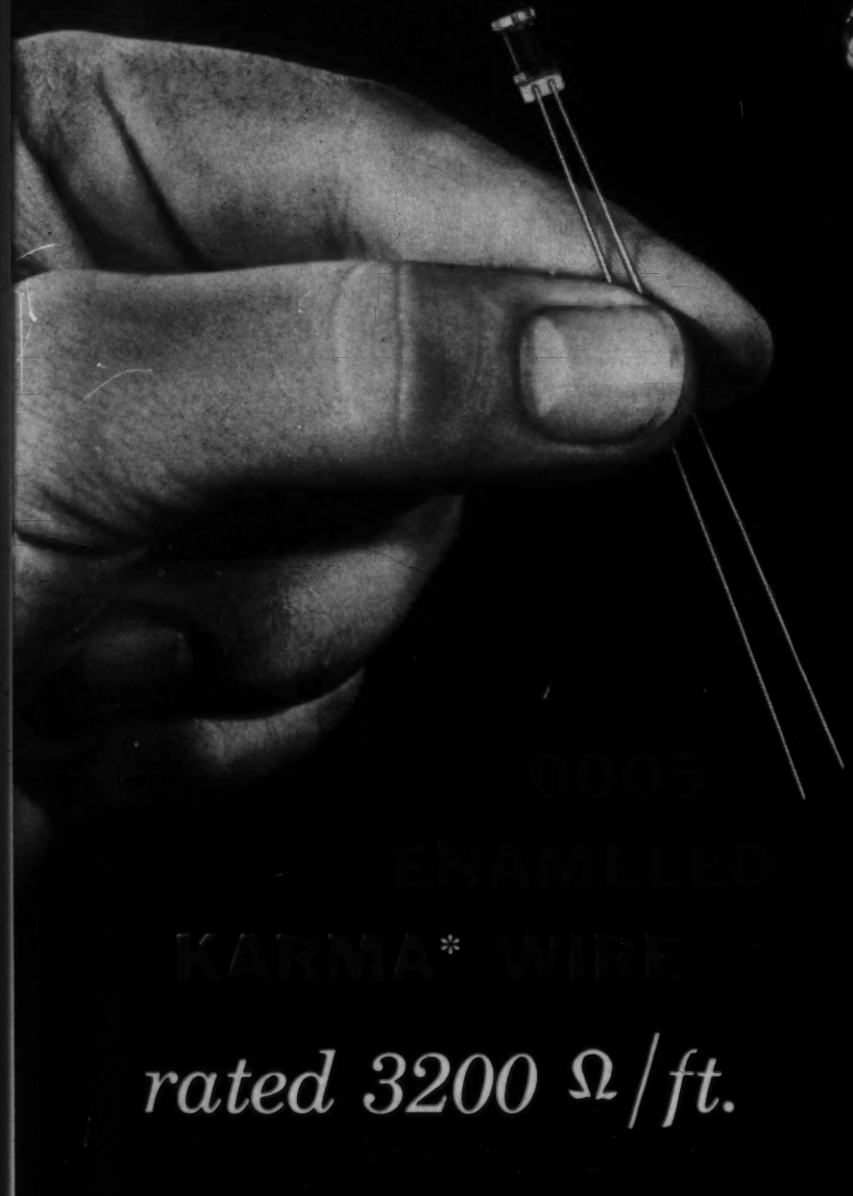
For more information, turn to Reader Service Card, Circle No. 450

Miniaturization takes a big step forward as Driver-Harris announces...



rated 3200 Ω/ft.

What this development can mean to resistor manufacturers is here dramatically illustrated. The large wire-wound resistor is rated at 1 megohm. The infinitely smaller one, wound with .0005 Enameled Driver-Harris Karma is rated at *1½ megohms.* In this particular application 50% more resistance or ½ megohm has been put on a ceramic spindle 1/5 the size of the original bobbin.

Even though we have succeeded in drawing Karma down to this fine size, its outstanding electrical and physical properties are maintained. Most important of these are:

- Low Temp. Coeff. of Resistance less than ± 20 parts per million
- Wider temperature range—65°C to 125°C
- Low thermal EMF against copper (equalled only by Manganin)
- High tensile strength combined with lower thermal expansion
- High resistance to oxidation

Add to these advantages the fact that the final cost per ohm is lower than in heavier sizes. Available now in commercial quantities. Complete data mailed on request.

*T.M. Reg. U. S. Pat. Off.

SPECIAL PURPOSE ALLOYS SINCE 1899 — D/H — TRADE MARK REG. U. S. PAT. OFF.

Driver-Harris COMPANY HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Louisville, Los Angeles, San Francisco In Canada: The B. GREENING WIRE COMPANY, Ltd., Hamilton, Ontario

MAKERS OF THE MOST COMPLETE LINE OF ELECTRIC HEATING, RESISTANCE, AND ELECTRONIC ALLOYS IN THE WORLD

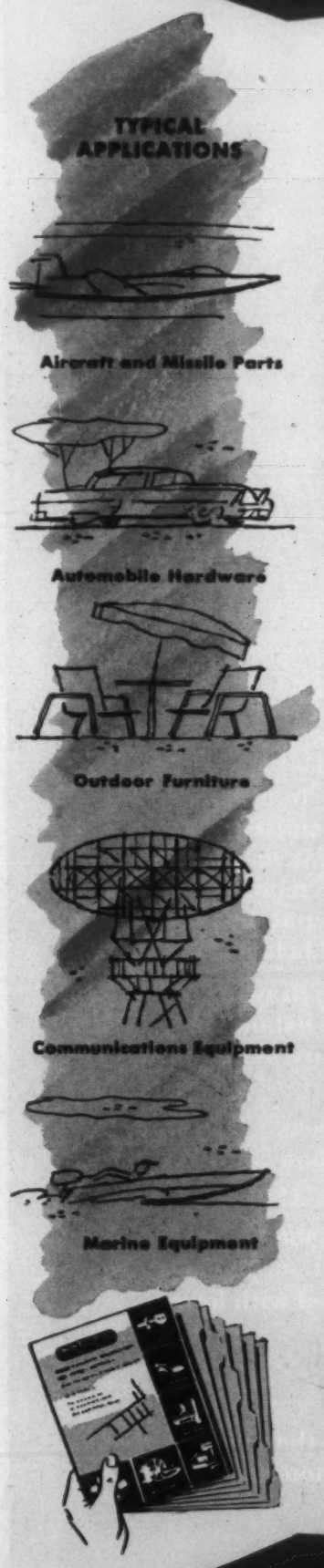
For more information, turn to Reader Service Card, Circle No. 452

look at these advantages of

IRIDITE FINISHES

for

CORROSION-RESISTANCE, PAINT BASE on ALUMINUM and MAGNESIUM



EASE OF USE—Iridite is a simple chromate conversion treatment. Fast, easy, economical. You just dip, brush or spray it on the part at room temperature. No special equipment. No specially trained personnel.

OUTSTANDING PERFORMANCE—Forms a film that is an integral part of the metal itself. Can't flake, chip or peel. Takes paint firmly on initial application, and the bond lasts. Even protects areas scratched in use.

LOWEST COST—You have only minimum equipment cost, no special racks, high speed operation, lower overall handling costs.

CHOICE OF APPEARANCE—Clear coatings that retain metallic lustre to dark, maximum protection coatings. A variety of colors is available by dyeing.

IRIDITE # 14 and # 14-2 (Al-Coat) for ALUMINUM

Two specially formulated finishes that give you maximum latitude in aluminum treatment. Both provide excellent corrosion protection and paint base. Iridite #14-2 is an improved product that allows greater flexibility in operation and coating thickness and produces the optimum in corrosion protection.
Either coating provides corrosion resistance superior even to complicated electrolytic treatments in a fraction of the time. These coatings also offer many other valuable characteristics: they have low electrical resistance, they aid in arc-welding, provide a good base for bonding compounds, have no effect on the dimensional stability of close-tolerance parts. Final appearances ranging from clear through yellow iridescence to full brown can be obtained. By dyeing, you can produce red, green, blue, orange or yellow finishes.

IRIDITE # 15 for MAGNESIUM

Produces a protective, paint base film with corrosion resistance at least equal to that obtained from long, high-temperature dichromate treatments in a fraction of the time and at room temperature. The appearance of the coating can be varied from light brown to dark brown and black.

APPROVED UNDER GOVERNMENT AND INDUSTRIAL SPECIFICATIONS

SEE FOR YOURSELF WHAT IRIDITE CAN DO . . . SEND SAMPLE PARTS FOR FREE PROCESSING. Look at the results, test the protection, evaluate the savings. Also write for handy Reference File of the most complete data published on chromate conversion coatings. Or, for immediate information, call your Allied Field Engineer. He's listed under "Plating Supplies" in your classified phone book.

ALLIED RESEARCH PRODUCTS
INCORPORATED
4004-06 E. MONUMENT STREET • BALTIMORE 5, MD

Manufacturers of Iridite Finishes for Corrosion Protection and Paint Systems on Non-Ferrous Metals; ARP Plating Chemicals.
West Coast Licensee—L. H. Butcher Co.

For more information, turn to Reader Service Card, Circle No. 517

OTHER NEW MATERIALS PRODUCTS

formers and for both wrapped and sintered wires and cables, the thin tape provides adequate dielectric strength with less Teflon area than thicker tapes. It is easier to handle in wrapping operations than thicker tapes, particularly on small diameter wire.

The tape is supplied in continuous rolls with a minimum of splices. Widths from ½ to 12 in. are wrapped to 6 in. o.d. on 1⅛ in. dia spools.

4. Printable Mylar tape

New printable tapes made from Du Pont's Mylar polyester film have been announced by *Permacel Tape Corp.*, New Brunswick, N.J. Known as Permacel 95 and 951, the pressure sensitive tapes are used for labeling and sealing.

P95 is a transparent tape and P951 is available in red, black, white and chrome, a metallized finish. The 1-mil Mylar film back is resistant to most common acids and alkalies as well as solvents and oils. The tapes have 20 lb per in. width tensile strength, 18 oz per in. width adhesion to steel, and 70% elongation. They are available in sizes from ¼ to 23 in.

5. Printable plastics tape

A plastics tape designed for printing and die cutting has been announced by *Minnesota Mining & Mfg. Co.*, Dept. L6-103, 900 Fauquier St., St. Paul 6, Minn.

The tape, a printable version of No. 471, is intended to meet the need for printed labels and seals that resist chemicals, heavy wear and limited weathering. It is expected to find use for fluid line identification in aircraft, and coding and identification in oil refineries, chemical plants and pipelines. In die cut shapes, 3M recommends the tape for traffic directions and point-of-sale messages.

Tensile strength of the tape has been increased 53% to 21 lb per in. of width. Adhesion has been increased 30% to 24 oz per in. of width. The tape has 150% elongation at breaking and is 6.5 mils thick. Available in yellow and

3 ways Glidden helps you produce better METAL POWDER PARTS

Superior metal powders — Glidden Resistox Metal Powders have been subjected to the most exhaustive tests by parts manufacturers. Result: parts made from Glidden metal powders are judged superior to parts produced from other powders. They permit faster production, with greatly improved finish, appearance and performance characteristics.

Complete field service and lab facilities — Whether you are interested in establishing a new metal powder parts department, or desire to improve operations of an existing department, Glidden can help you. The Glidden metal powders lab and the services of Glidden technicians are available to your metallurgists at any time.

World's largest blender — Glidden can produce up to 30,000 pounds of powder in one batch, more than any other producer... an important factor in complete uniformity of mass-produced parts.

A thorough examination of the manufacturing methods you are now using may lead to substantial savings. Make certain you are not passing up the economies, speedier fabrication and superior parts performance you can get by using Glidden Resistox Metal Powders. Write for complete details.

THE GLIDDEN COMPANY

Chemicals — Pigments — Metals Division

Baltimore, Md. • Collinsville, Ill.
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QUALITY Glidden PRODUCTS — CHEMICALS PIGMENTS METALS

* For more information, turn to Reader Service Card, Circle No. 416

HERE'S HOW...

INVESTMENT CASTING ANSWERS DESIGN PROBLEMS

Investment Casting is a specific production method that fills a specific function. This process offers much greater latitude in shape, detail reproduction and choice of alloy than any other process.

IN SHAPE

The picture tells the story . . . from the cross section it can be seen that the inside dimensions are greater than the holes. How else but by Investment Casting could this be made in one piece?

IN DETAIL REPRODUCTION

One look quickly shows the machining problems — most of them stock removal. By using an Investment Casting 21 out of 45 machining operations were eliminated.

IN MATERIAL

These nozzles for a highway striping paint sprayer, were produced from cold rolled steel until ground glass was introduced into the paint for its reflective properties. To provide necessary wear resistance these parts are now cast in a non-machinable alloy. Performance was not sacrificed because of material limitations.

These are a few examples demonstrating that the function of the part is the first consideration in design — and — the Investment Casting process was the economical answer.

For more information ask for our brochure . . . its FREE of course.

HITCHINER
Manufacturing Company
MILFORD 3, NEW HAMPSHIRE
REPRESENTATIVES IN PRINCIPAL CITIES

For more information, turn to Reader Service Card, Circle No. 407

white, it is made in 36 and 108-yd rolls in widths of ½ in. and more and in 36-yd rolls in widths of less than ½ in.

Ceramic Resistant to Thermal Shock

A new ceramic is claimed to have such a low expansion coefficient, along with high density, that it can be used in extreme heat shock applications up to 2500 F. Designated Sur-Braze Grade HT-2, it is made by *Technion Design & Mfg. Co.*, 262 Mott St., New York.

The material, a modified aluminum silicate, is made in rods, bars, rounds and flats, which can be machined with carbide tipped tools. Its coefficient expansion of 10 x 10^{-7} in. per in. per deg F allows thermal shocks without spalling or cracking. Its low porosity permits use in liquid quenching media, because it is not subject to explosive cracking when reheated.

Sur-Braze Grade HT-2 is used in heat treating and brazing fixtures and jigs. Plates with close tolerance milled slots are used in high production brazing of precious metal contacts. The plates are also used in sintering applications in place of carbonaceous compounds because HT-2 will not contaminate metal parts or the atmosphere.

New Rubber Resists Ultraviolet Light

A new light colored nitrile rubber has been developed by *Chemical Div., Goodyear Tire & Rubber Co.*, Akron 16, Ohio. Designated Chemigum, N6B, and made by using an improved antioxidant system, the rubber is a nonstaining, nondiscoloring version of Goodyear's Chemigum N6.

Both products are essentially

For more information, Circle No. 565 >

equal in physical and gum properties and extremely close in compounded properties before and after aging. Fadeometer exposures of the new rubber, however, show it to have superior resistance to discoloration. It is to be used in light colored flooring, clear cements and where resistance to ultraviolet light or photochemical degradation is needed.

Hot Melt Compound Used with Honeycomb

Machining of stainless steel honeycomb structures is now possible because of a new hot melt compound. Known as Hot-Melt H-883-A, it has been developed by *Furane Plastics, Inc.*, 4516 Brazil St., Los Angeles 39.

Without proper support during machining, stainless steel honeycomb structure will collapse or tear, making accurate dimensions impossible. The new compound with its extremely low linear shrinkage maintains the cells of the honeycomb during machining. The cells do not tend to collapse or fray, a problem that occurs with waxes or similar space fillers.

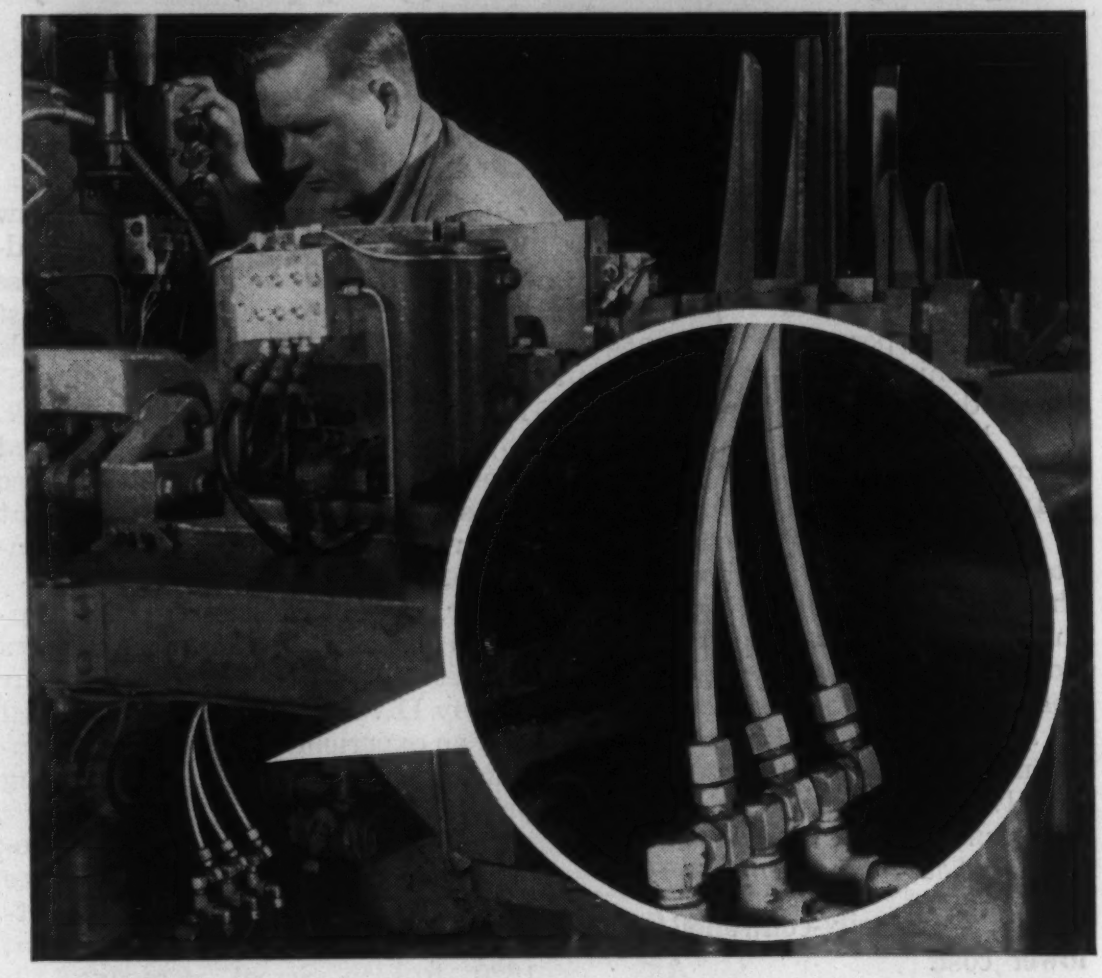
In practice, the hot melt compound is melted at a temperature near 200 F in stainless or aluminum pans, and the honeycomb is inserted. After cooling and machining, the compound is melted from the honeycomb and the honeycomb is cleaned with hot water.

Friction Coated Nylon for Layer Insulation

A friction coated Mylar polyester film has been developed by *Dobeckmun Co.*, 3301 Monroe Ave., Cleveland, Ohio, for use as layer insulation for transformers.

The film, which can be of any gage, is provided with a special "843" friction coating on one or both sides. The high coefficient

NYLAFLOW® Pressure Tubing cuts costs on machine tool lubrication systems



• High-speed production soon becomes "high-cost" production in the face of frequent downtime and expensive maintenance. Polymer's NYLAFLOW Pressure Tubing — specially processed from tough, horn-like nylon — helped solve this problem recently on a series of automatic machines:

PROBLEM:

Tubing connecting automatic lubricator to moving parts was required to withstand 400 flexes per minute under high internal pressure. Frequent failure due to pressure and flex fatigue of tubing caused excessive downtime, costly maintenance.

SOLUTION:

NYLAFLOW Pressure Tubing has been in continuous use for 12 months without a single replacement. This represents an increase in tubing life—*thus far*—25 to 1 over former tubing. NYLAFLOW required no special fittings, was less bulky and easily installed.

These characteristics show why tubing costs are low with NYLAFLOW:

- Flexibility—extremely long flex life.
- High Pressure Rating — higher strength / weight ratio than any other extruded non-metallic tubing.
- Easy Installation—light weight, easy to handle and cut, no pre-bending, uses standard fittings.
- Corrosion Resistant—impervious to most chemicals, hydrocarbons, solvents.
- Impact and Abrasion Resistant—withstands accidental blows which permanently dent metal tubing, resists surface wear.

Solve your tubing problems permanently with economical NYLAFLOW. Available in burst strengths of 1000 and 2500 psi. in various diameters. Write for performance data.

THE POLYMER CORPORATION OF PENNA. • Reading, Penna.
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POLYPENCO Nylon, Teflon*, Q-200.5 and K-51

*DU PONT TRADEMARK

For more information, turn to Reader Service Card, Circle No. 421

Aluminux etching process improves anodic coating appearance, prevents rock-hard scale in tanks

As the trend to aluminum anodizing gains momentum, many firms are discovering that Diversey's Aluminux process is an ideal preparation for many types of anodic coatings. The Aluminux process produces an even, diffused, satin-finish, giving more lustre and greater uniformity of color to the anodized product.

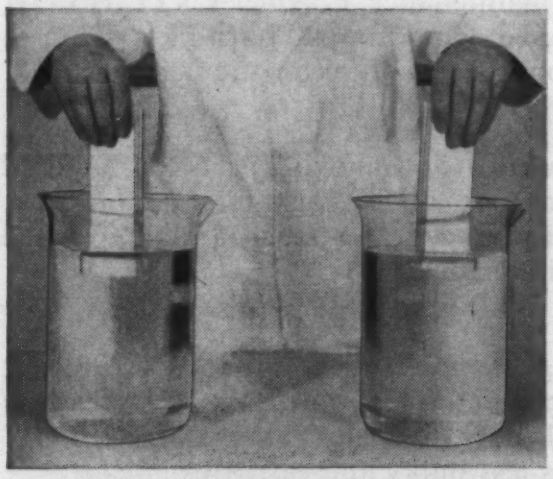
In addition to delivering a superior finish, Aluminux prevents scale in etching tanks. As the photos below show, Aluminux holds dissolved aluminum in solution, instead of depositing it on tank walls and heating coils in the form of sludge and scale. In a 1500 gallon tank, for instance, Aluminux holds up to 1,000 lbs. of dissolved aluminum in solution . . . *a potential one ton of scale that would otherwise have to be chipped off!*

Better, more easily-controlled etch at lower cost.

The production-line performance of Aluminux during the past few years has proved its remarkable advantages. These include: (1) far less frequent dumping . . . solutions last up to 4 times longer with no scale build-up, (2) superior, even, diffused satin-finish and cleaner work, (3) faster rate of etch and increased production, (4) lower maintenance costs . . . tanks are simply hosed out when re-charging, (5) precision control of degree of etch.

For more facts about the exceptional savings other manufacturers are getting with Aluminux, ask your nearby Diversey D-Man. You'll find him an experienced, dependable consultant on your metal finishing problems.

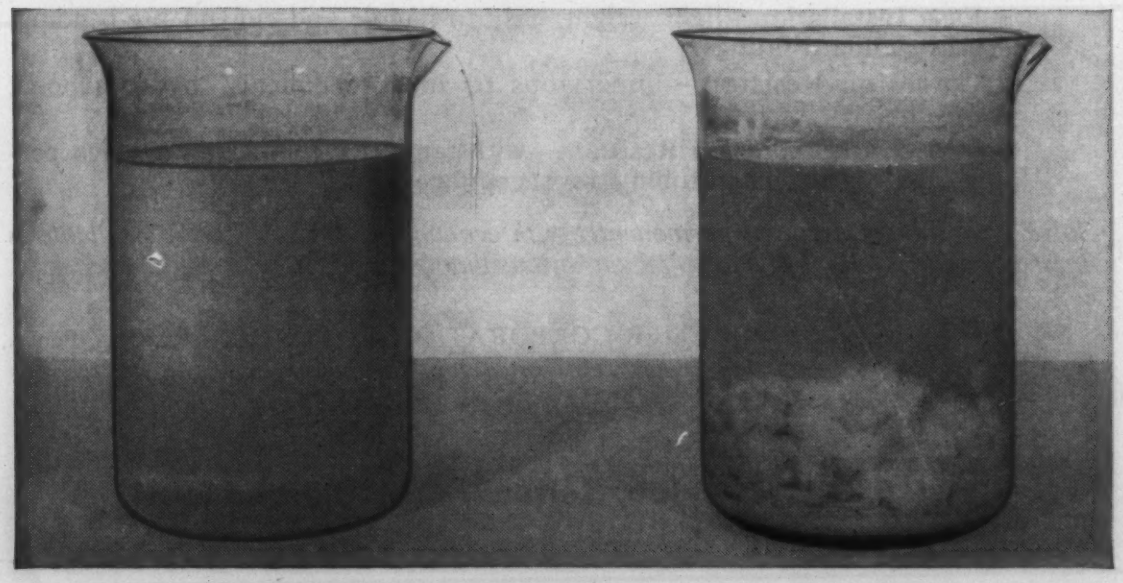
For an interesting illustrated brochure on the Aluminux process, write today to Metal Industries Department, The Diversey Corporation, 1820 Roscoe Street, Chicago 13, Illinois.



Why Aluminux process prevents scale build-up

1. IDENTICAL ALUMINUM EXTRUSIONS are placed in equal-strength solutions of Diversey Aluminux (left) and an ordinary etchant (right).

2. ALUMINUM HAS NOW BEEN DISSOLVED IN BOTH SOLUTIONS, but look at the difference! In the Aluminux solution at left, the dissolved aluminum has been held in solution with no trace of precipitate. But, in the ordinary etchant at right, the solution is cloudy with a heavy precipitate. This precipitate is aluminum oxide, the deposit that builds up as rock-hard scale inside your etching tanks.



For more information, turn to Reader Service Card, Circle No. 445

of friction achieved on the otherwise slippery surface of the film eliminates wire slippage in the winding operation. The translucency of the coating permits a visual check on the position of wires during winding. Unlike plain Mylar, which often repels varnish, the coated film is readily wet by varnish.

Tests have revealed no change in dielectric strength of the polyester film and no significant change in thermal stability after friction coating. Samples subjected to 300 F for 18 hr turned light tan in color, but there was no apparent effect on adhesion of the coating.

The friction coated Mylar film is available in widths up to 35 in.

Low Alloy Wire for Welding T-1 Steel

A chromium-nickel-molybdenum alloy automatic welding wire with less than 2% total alloy content is available from *American Chain & Cable Co., Inc.*, 929 Connecticut Ave., Bridgeport 2, Conn. Designated A-S-8620 and of standard AISI low alloy content, it is well suited for welding U. S. Steel's "T-1," a high strength constructional steel.

With proper flux (submerged arc) on T-1 Steel, the wire provides a weld having tensile strength of 114-116,000 psi, elongation of 12-15% and Rockwell hardness of C28-30. Chemical analysis as welded is close to that of the parent T-1 Steel.

Tubing for Packages Made from Nylon 6

Extruded blown lay-flat nylon tubing is available from *Kemtek Corp.*, 206 Sylvan Ave., Newark 4, N. J., in experimental quantities. The material used is Type 6 nylon, a high strength polymer

M & T CONTROLLED-ARC POWER SUPPLY

for semi- and full-automatic welding

Here's another new Metal & Thermit product — the M & T constant voltage rectifier-type DC Welder as developed originally by the Glenn Co. When used in conjunction with a constant speed wire feed for semi- and full-automatic welding, it . . .

SIMPLIFIES OPERATION — for all practical purposes it maintains a constant arc length during entire welding cycle, thereby assuring a uniform deposit.

IMPROVES WELDING — uniform deposits are of high quality, regardless of conditions which normally affect arc length such as poor fit-up, tack welds, etc. — avoids undercutting on horizontal welds.

SPEEDS PRODUCTION — instantaneous starting and recovery get job underway faster with higher average rate of deposit — practically eliminates rejects.

CUTS POWER AND INSTALLATION COSTS — high efficiency and power factor permit lower wiring and operating power costs.

M & T Controlled-Arc Power Supply units are saving time and cutting costs on many semi- and full-automatic welding operations. Write for details on how they can help you.

WELDING SUPPLIES
RADIOGRAPHIC EQUIPMENT
PLATING MATERIALS
ORGANIC COATINGS
CERAMIC MATERIALS
TIN & TIN CHEMICALS
METALS & ALLOYS
HEAVY MELTING SCRAP

METAL & THERMIT
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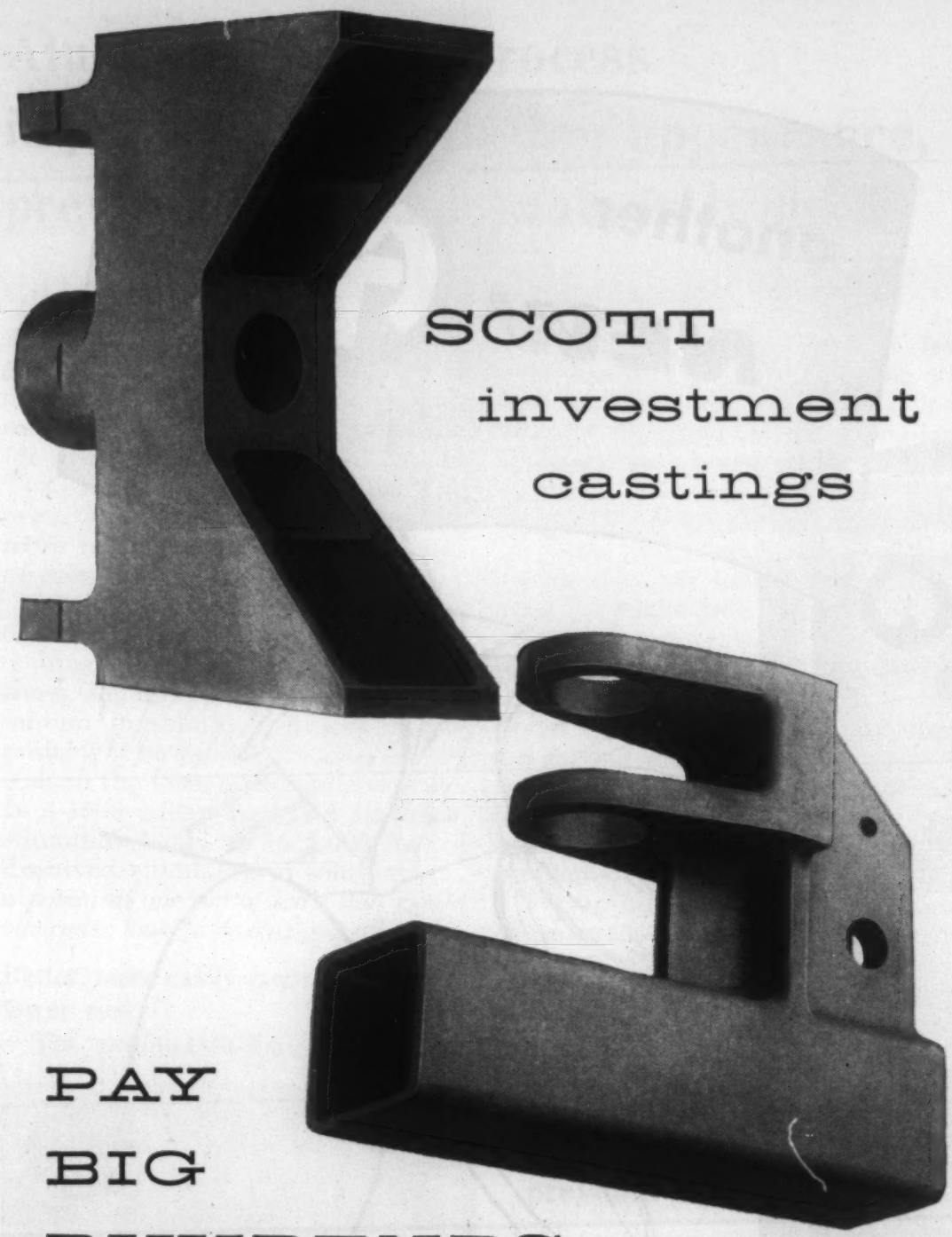

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castings

PAY
BIG
DIVIDENDS

You save considerable time, trouble, and expense when Scott investment casts your ferrous or non-ferrous parts.

Time, because Scott experience speeds the entire process of designing the part for casting. Scott specialists work with you right through from start to finish.

Trouble, because this division of Rolle is capable of taking the entire responsibility for casting performance. Petty day-to-day annoyances become Scott's worry, rather than yours.

Expense, because Scott takes a direct approach to every casting problem, eliminating false starts and waste. Scott's priceless years of actual production experience assure you maximum return on every investment casting dollar.

Further, as a Division of Rolle Manufacturing Company, Scott can offer you the most complete laboratory test and quality control facilities.

WRITE NOW for complete information on Scott's facilities for increasing your dividends on investment casting.

SCOTT
CASTINGS

DIVISION OF ROLLE
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303 Cannon Avenue,
Lansdale, Pa.

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based on caprolactam (see M&M, May '55, p 108).

Advantages of this nylon material are:

1. *Easily sterilized*—The nylon has a melt temperature of 420 F. It will withstand either steam or dry sterilization in an autoclave with no loss of physical properties.

2. *Chemically resistant*—Type 6 nylon is generally resistant to most solvents. It is adversely affected only by strong mineral acids.

3. *Heat sealable*—The film can be sealed by either radio frequency or thermal impulse sealers to a strong permanent seal.

4. *Printable*—Unlike polyethylene film, this nylon film can be clearly and permanently printed without special treatment by any of the standard printing methods.

5. *Nonbreathing*—A sealed nylon bag resists passage of oxygen and other gases and liquids, but allows a slight transfer of water vapor.

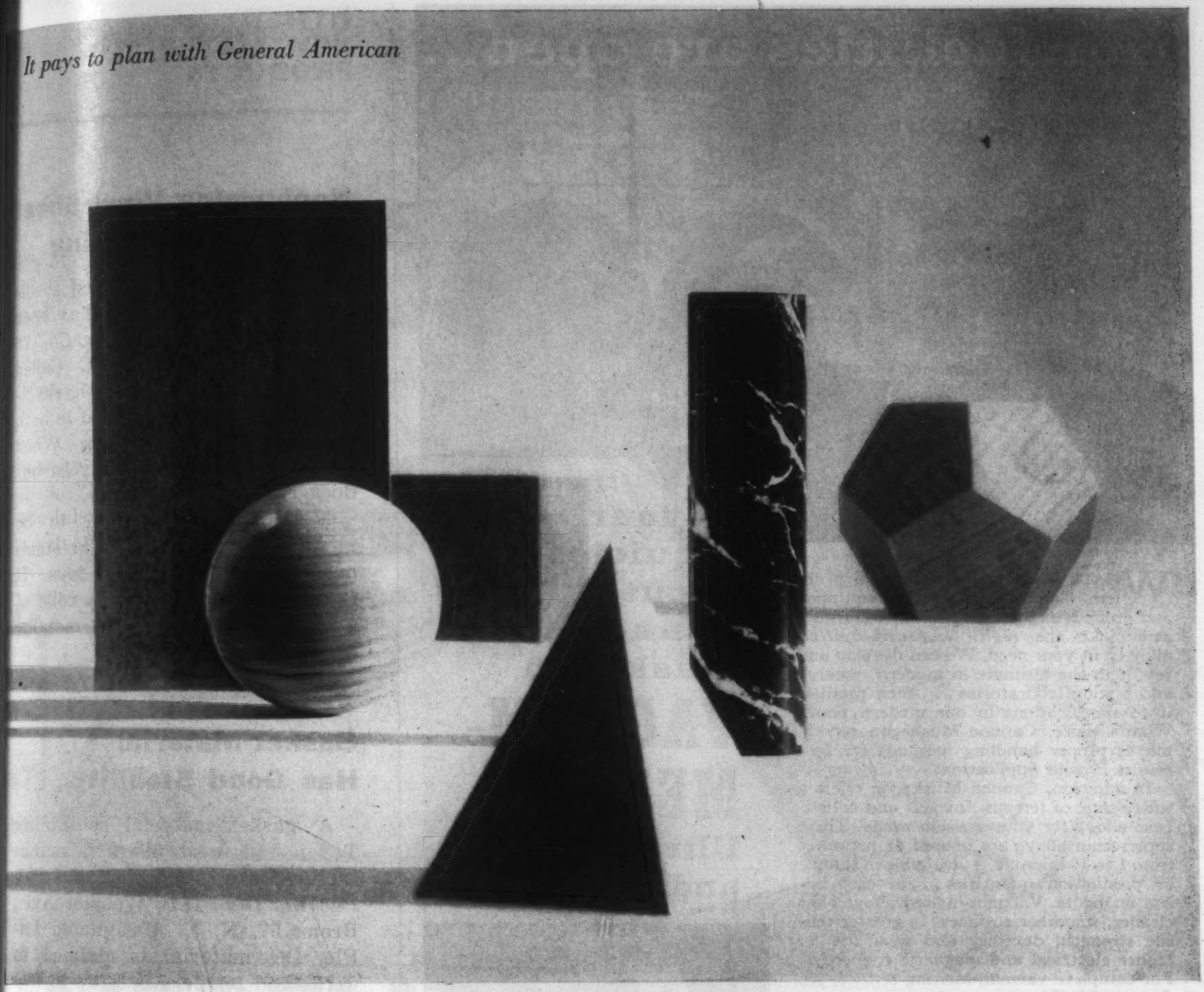
Silicone Rubber for Ducting Cloth

A silicone rubber cloth coating compound for ducting has been developed by *Silicone Products Dept., General Electric Co.*, Waterford, N. Y. Designated SE-701, the compound is suitable for ducting exposed to air at temperatures as high as 700 F. The compound remains flexible at temperatures as low as —120 F.

SE-701 resists flow under clamps, has good flame retardancy, and has low swell in such fluids as Skydrol 500 and 700, JP4, gasoline, MIL-o-7808 and MIL 5606. Applications include hot air ducts, jet engine starter hose, flexible connectors for metal ducting and aircraft fire wall seals.

(more New Materials on p 186)

It pays to plan with General American



a whole new world of profit opportunities with **GEN®**

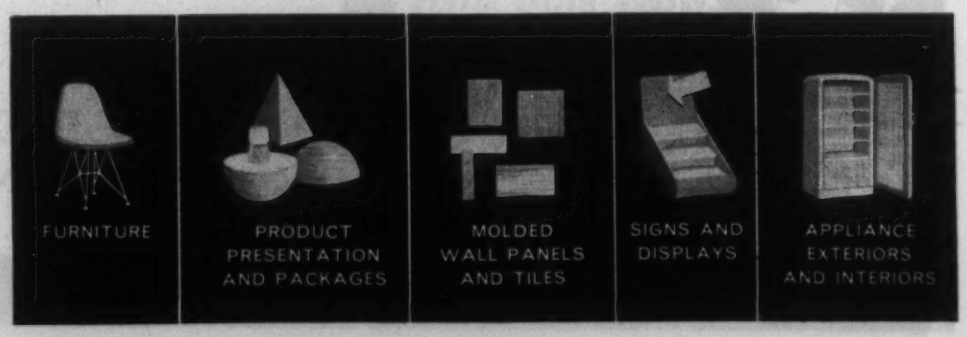
General American's new material offers unexplored possibilities for packaging, furniture, building and a host of other uses!

Now, anything that can be photographed can be duplicated on Gen—a completely new idea in decorative plastic sheeting. By means of an exclusive process, General American's Plastics Division now offers sheeting and formed parts that bear perfect reproductions of leather, marble, wood grain, fabric—any material, pattern or design.

Gen-715, the first of a series, can be vacuum formed on conventional equipment or produced to your specifications, by General American. It is available in standard widths up to 40 inches and in any desired lengths—thicknesses from .040 inches to .187 inches.

Where can you use GEN? In appliance interiors and housings? Product presentation and packaging? Furniture? Wall and ceiling tile? Advertising specialties? Displays and signs? Three-dimensional paneling? *Where can you use Gen?* Find out. Write to General American for samples and descriptive literature.

PLASTICS DIVISION
GENERAL AMERICAN TRANSPORTATION CORPORATION
135 South La Salle Street, Chicago 90, Illinois
Facilities unmatched anywhere: injection, compression, extruding and vacuum forming, reinforced plastics, painting and assembling.



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Our facilities are open...

to your inquiries about Cannon-Muskegon

VACUUM-MELTED

UltraMet alloys and service

WHATEVER your metallurgical problem, Cannon-Muskegon is equipped and staffed to solve it. Our metallurgists can make the *right vacuum-melted* alloy to fit your need. We can develop and test it in the ultimate in modern research and testing laboratories . . . then produce it to specifications in our modern plant. What's more, Cannon-Muskegon recommends proper handling methods for best results in your application.

In addition, Cannon-Muskegon offers a wide range of ferrous-, nickel- and cobalt-base alloys for your specific needs. These super-clean alloys are poured at pressures from 1 to 10 microns — available in sample or production quantities . . . in cast billets or ingots. Vacuum-melted alloys offer cleaner, smoother surfaces . . . greater tensile strength, ductility and wear life . . . higher electrical and magnetic properties. For complete vacuum-melting service, see Cannon-Muskegon.

Now available are:

- ***Materials for remelt*** — under conventional air melting, inert gas, vacuum.
- ***Casting development*** — includes research and experimental facilities for investment, shell mold, dry sand, and permanent mold castings.
- ***Ingots or cast billets*** — for rolling, forging or extruding in individual weights up to 250 pounds.

ULTRA MET
VACUUM-MELTED ALLOYS
FOR INDUSTRY

MODERN RESEARCH facilities and experts are at your service. Constant research with known alloys develops our abilities . . . to your advantage. We are now testing alloys containing boron, aluminum and titanium . . . with interesting results. Send us your problems.

For full particulars write for our New Bulletin on Vacuum-Melting and Air-Melting facilities and products.

CANNON-MUSKEGON CORPORATION
2873 Lincoln Street Muskegon, Michigan

METALLURGICAL SPECIALISTS

For more information, turn to Reader Service Card, Circle No. 430

OTHER NEW MATERIALS PRODUCTS

Nonburning Vinyl Sheet for Vacuum Forming

A rigid vinyl metallized sheeting that will not burn has been developed by *Gomar Mfg. Co.*, 79 Paris St., Newark, N. J. Called Metalcote, the vinyl plastic sheeting can be vacuum formed in both shallow and deep shapes. When placed in a flame it shrivels, but does not flare or explode.

Metalcote is expected to be particularly useful for Christmas ornaments, displays and toys. It is available in continuous rolls of 0.005-in. thickness in 18 metallic colors.

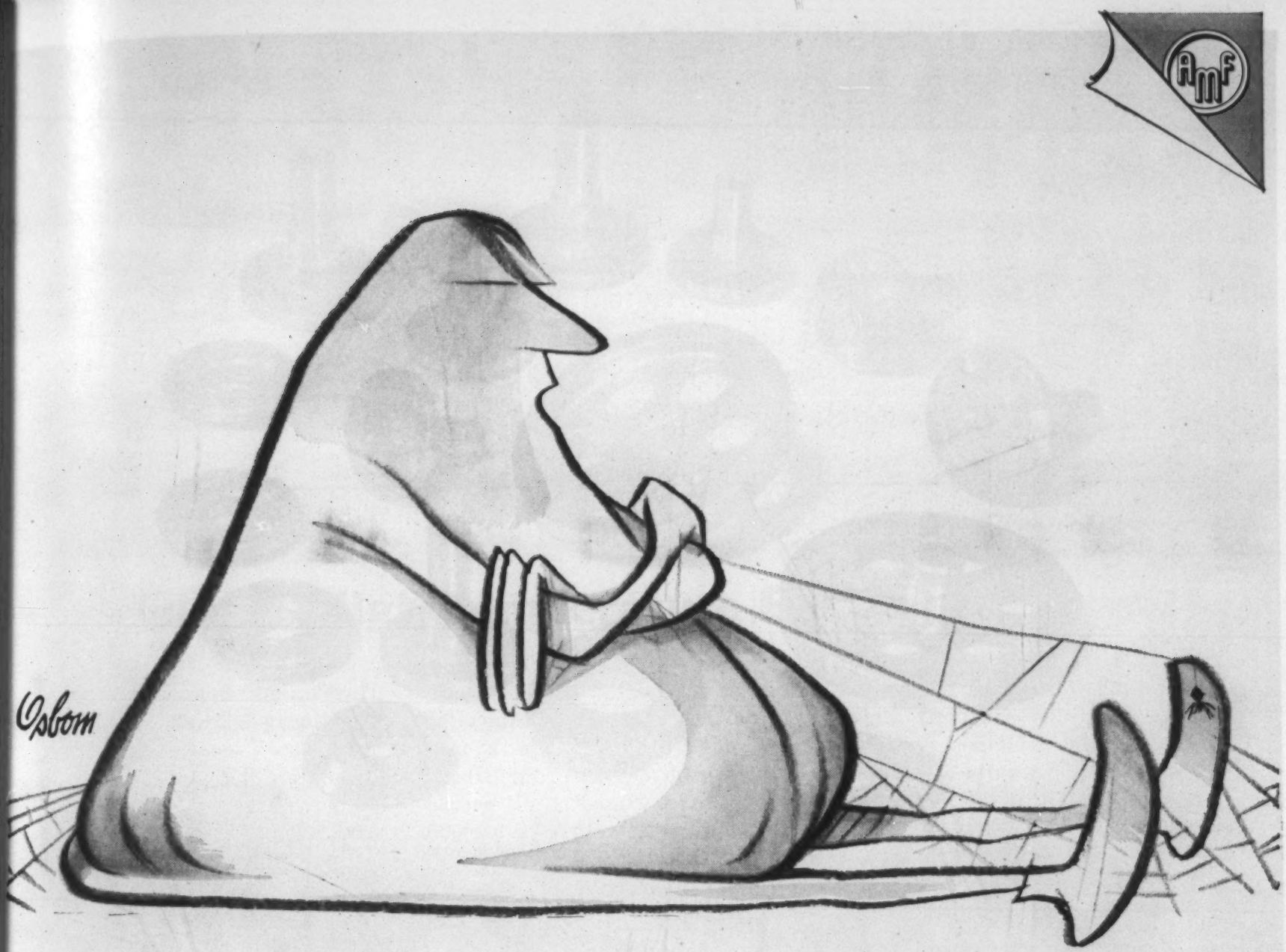
Gasket Material Has Good Stability

A gasket material containing Teflon and inert fillers is manufactured by *Balfor Industries Packing Div.*, 1815 Webster Ave., Bronx 57, N. Y. Designated Lo-Flo, the material is claimed to withstand temperatures up to 600 F with no distortion. It is also resistant to the inherent cold flow characteristics of pure Teflon.

Colored blue for identification, Lo-Flo is available in widths up to 8 in. and in thicknesses ranging from 1/64 to ¼ in.

Aluminum Tread Plate

Nonskid abrasive aluminum tread plate is available from *Aluminum Co. of America*, 1501 Alcoa Bldg., Pittsburgh 19. The slip-proof abrasive plate is designed for bus steps and aisles, marine and printing press catwalks, military gun mounts, passenger trains and truck and trailer floors. The plate is rolled from ingot by a method that provides a fused aluminum oxide abrasive on one surface. It can be fabricated by most commercial methods, including shearing, sawing, punching and drilling.



INERTIA ...can cost you money if you still specify bulky cast or forged circular parts. Here's how you can save three ways.

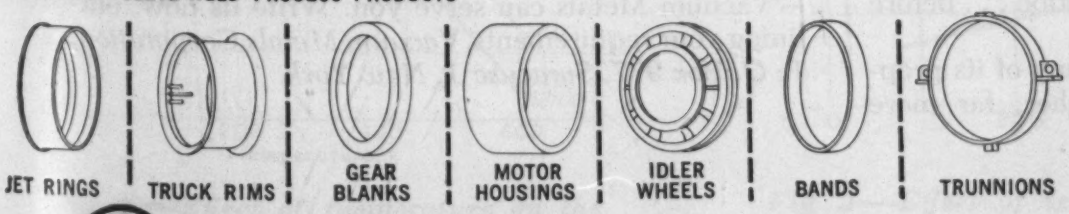
Cut costs three ways with circular parts from Cleve-Weld

1. Cut your waste costs up to 30% over bulky cast or forged parts.
2. Reduce finished machining time to a minimum.
3. Speed your overall production.

From simple gear blanks to special alloy jet rings, the Cleve-Weld Process gives the same results—better performance and reduced costs. *Often the savings in machine time and material waste alone pay for the finished Cleve-Weld part.*

Find out the full story on how Cleve-Weld's 45 years of design, metallurgical and production experience can save you money, improve your product. Write or send drawings to Circular Welded Products Sales Department at address below.

EXAMPLES OF CLEVE-WELD PROCESS PRODUCTS



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CLEVELAND WELDING DIVISION
AMERICAN MACHINE & FOUNDRY COMPANY
Cleveland 11, Ohio

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Cleveland Welding Division
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West 117th Street and Berea Road
Cleveland 11, Ohio

Please send me your brochure on the cost-cutting Cleve-Weld Process.

Name_____

Title_____

Attach to your company letterhead and mail

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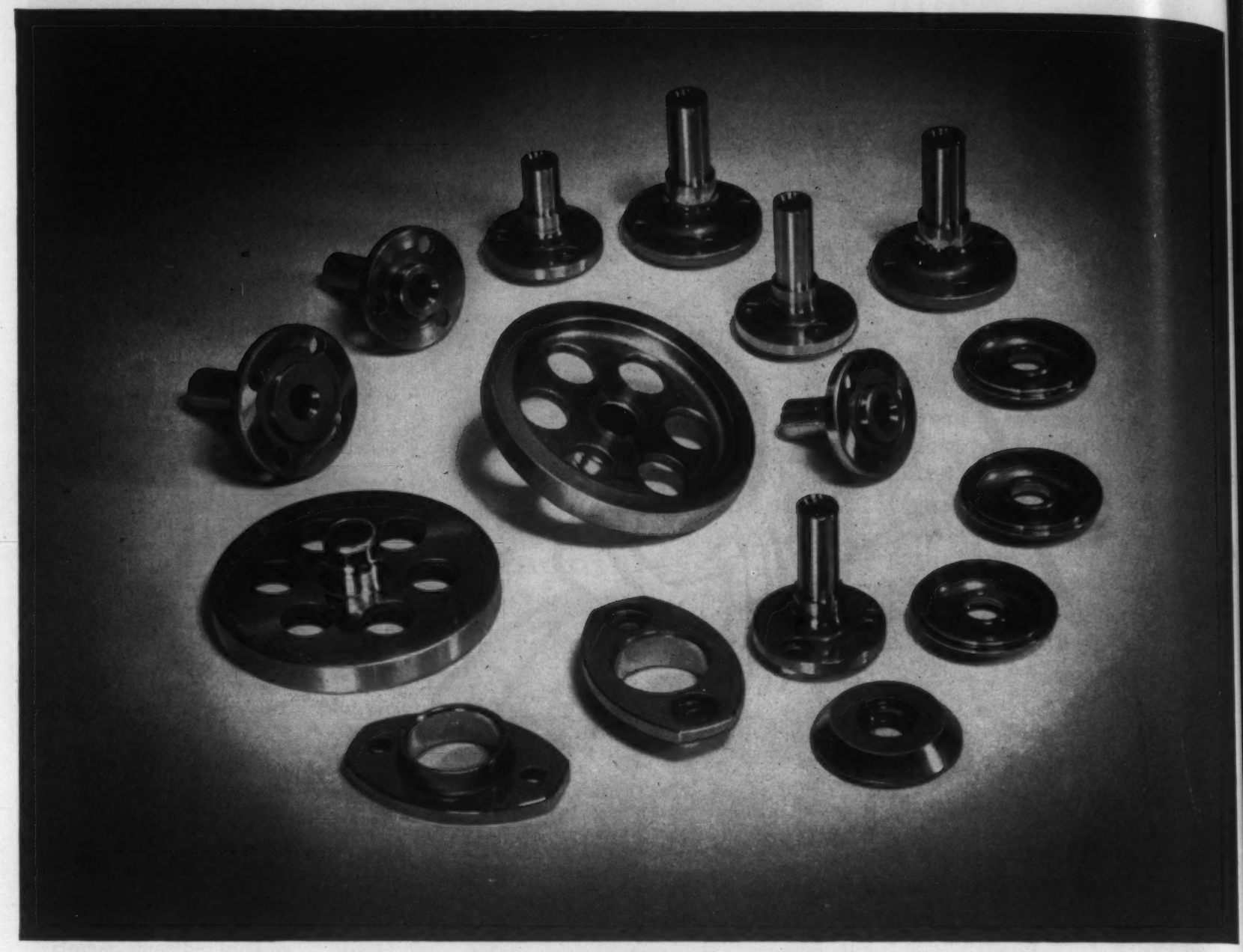

bearing manufacturer gains over 300% higher yield with Vacuum Metals FERROVAC

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CONTENTS NOTED

Highlights of current papers, plus a list of recent books and reports.

This Month

- *High temperature bearing materials*
- *Simplified treatment for tin plate*
- *Nickel-tungsten alloys*
- *New magnet wire insulations*

Materials for High Temperature Bearings

■ With the advent of the aircraft turbine power plant, a great deal of attention has been focused on the development of ball and roller bearings capable of operating at high speeds and temperatures without failure. In addition to the factors of size, loading, temperature and speed, material selection plays an important part in determining bearing reliability over a wide range of operating conditions. In a paper presented before the annual meeting of the Society of Automotive Engineers in Detroit last January, John Preston, Jerome Mogul and G. K. Floroff of Curtiss-Wright Corp. discussed some of the new materials that are available for improving bearing design.

Available alloys

The criterion of hot hardness is often used to determine the suitability of bearing steels and it is believed that successful operation depends to a large extent on

COMPOSITION OF STEELS FOR HIGH TEMPERATURE BEARINGS

	C	Cr	Al	Mo	Va	W
SAE 52100	1.0	1.45	...	...	...	...
MHT	1.0	1.45	1.50	...	...	...
Halmo	0.6	4.25	...	5.25	0.55	...
M-1	0.8	4.00	...	9.00	1.00	1.50
18-4-1	0.7	4.00	...	...	1.20	18.00

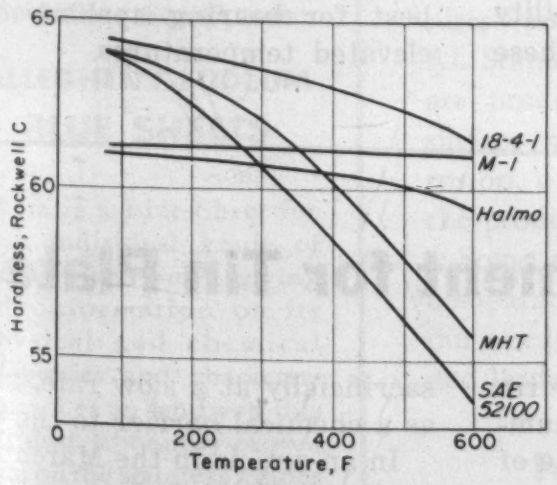


***Fig 1**—Effect of temperature on the hot hardness of typical bearing materials (races, balls and rollers).*

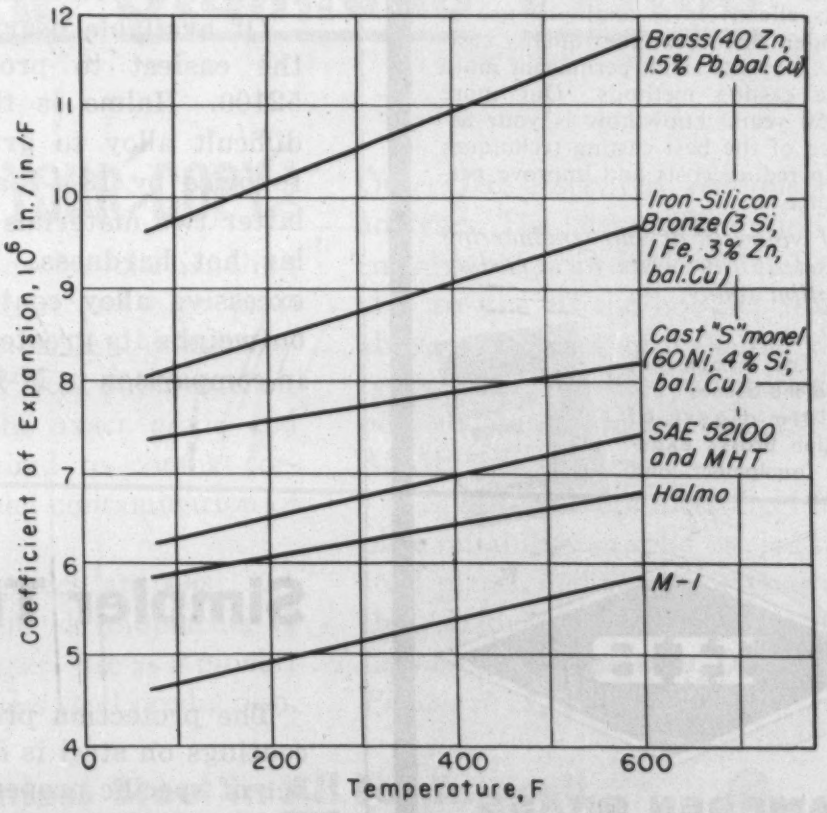
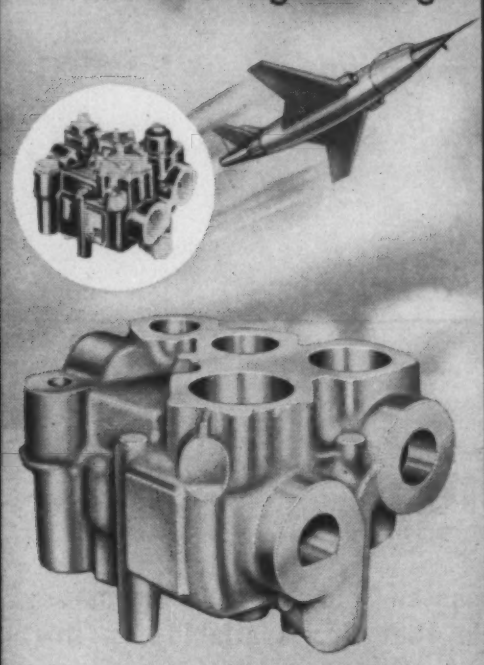


***Fig 2**—Effect of temperature on coefficient of expansion of bearing materials (for races, balls and rollers) and typical bearing cage materials.*

Chandler-Evans
depends on
HAMPDEN BRASS
for
Main Housing Casting



The Engineers and Facilities of HAMPDEN BRASS were called upon by Chandler-Evans to help develop and cast this main housing.

The sand casting process was chosen because the intricate cores could be cast at lower cost while still maintaining high quality standards. Hampden Brass is proud to produce the main housing casting for Chandler-Evans's RC-9 Afterburner Control used on turbojet engines.

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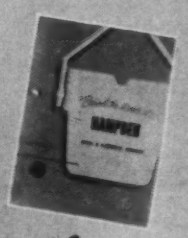

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the ability of the materials to maintain a hardness of about Rockwell C 60 at operating temperature (see Fig 1). Based on this requirement, use of the following materials is indicated at elevated temperatures: up to 350 F—SAE 52100 and MHT; up to 450 F—Halmo and M-1.

The slightly higher hot hardness of MHT compared to SAE 52100 is outweighed by the greater difficulty in producing a clean MHT steel by conventional air melting. Chief advantage of Halmo and M-1 steels is that they are tempered above the operating limit of 450 F. In contrast, SAE 52100 bearings are tempered at about the maximum operating temperature and are susceptible to over-tempering if they overheat during operation.

M-1 steel also possesses the lowest coefficient of expansion of currently used bearing steels, whereas SAE 52100 possesses the highest. Since a low coefficient of expansion minimizes dimensional instability, M-1 steel is quite effective in maintaining a low coefficient of friction.

Of available bearing materials, the easiest to process is SAE 52100. Halmo is the next most difficult alloy to grind and it is followed by 18-4-1 and M-1. The latter two materials possess similar hot hardness. However, the excessive alloy content of 18-4-1 outweighs its greater grindability in comparison to M-1. From these data it appears that the two most promising bearing materials capable of operating up to 600 F are Halmo and M-1. Because of its lower alloy content, it is possible that the Halmo alloy may prove to be the more suitable.

Cage materials

Selection of materials for the cage in a bearing has not been a major problem to date. However, as operating temperatures increase, this component will certainly require more attention. Currently, SAE 52100 and M-1 bearings generally contain a wrought, silver plated, iron-silicon bronze cage. This material is considered suitable for bearings operating up to 350 F.

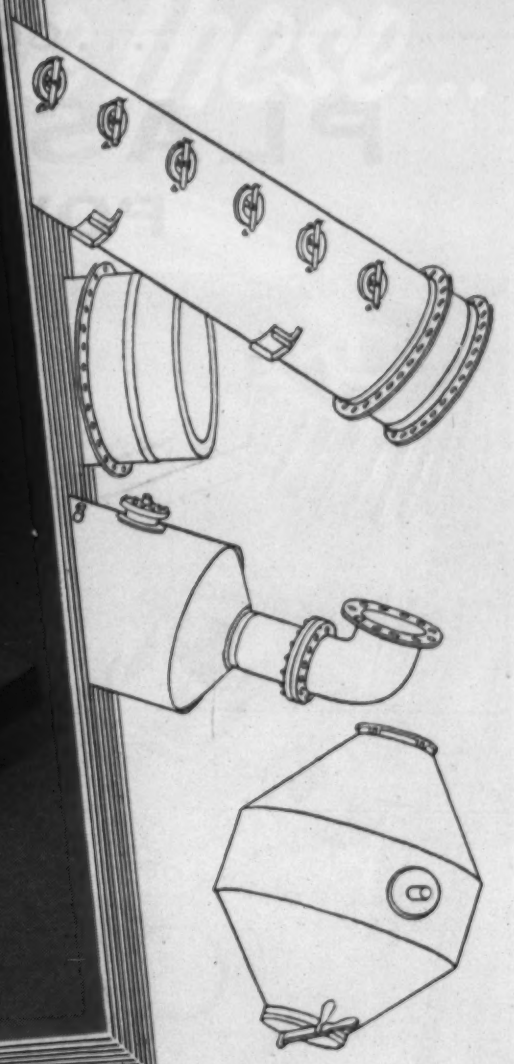
For higher temperatures cast "S" monel with a black oxide finish is being considered as the cage material for Halmo and M-1 bearings. This alloy possesses a low coefficient of expansion. In addition, it is resistant to galling or seizing where sliding motion occurs.

It is believed that a successful high temperature bearing should contain materials in the cage, ball and race that have similar coefficients of expansion. Accordingly, Fig 2 indicates that the combination of Halmo and cast "S" monel should produce a satisfactory bearing capable of operating up to 600 F. Laboratory data also indicate that the combination of a cast and a wrought material is best for bearing applications at elevated temperatures.

Simpler Treatment for Tin Plate

The protection provided by tin coatings on steel is due to a number of specific properties, some of which are best exhibited on exposure to food. Normally, when tin is exposed to moist air it is cathodic to steel. Inside a food container, however, tin is generally anodic to steel and dissolves sacrificially at a slow rate, acting as a chemical barrier to the steel.

In an article in the March issue of *Sheet Metal Industries* (British), Ernest S. Hedges, director of the International Tin Research Council, outlines some of the limitations of tin plate coatings and describes a chemical treatment



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whereby their protective value, particularly their resistance to staining, could be considerably improved.

Causes of staining

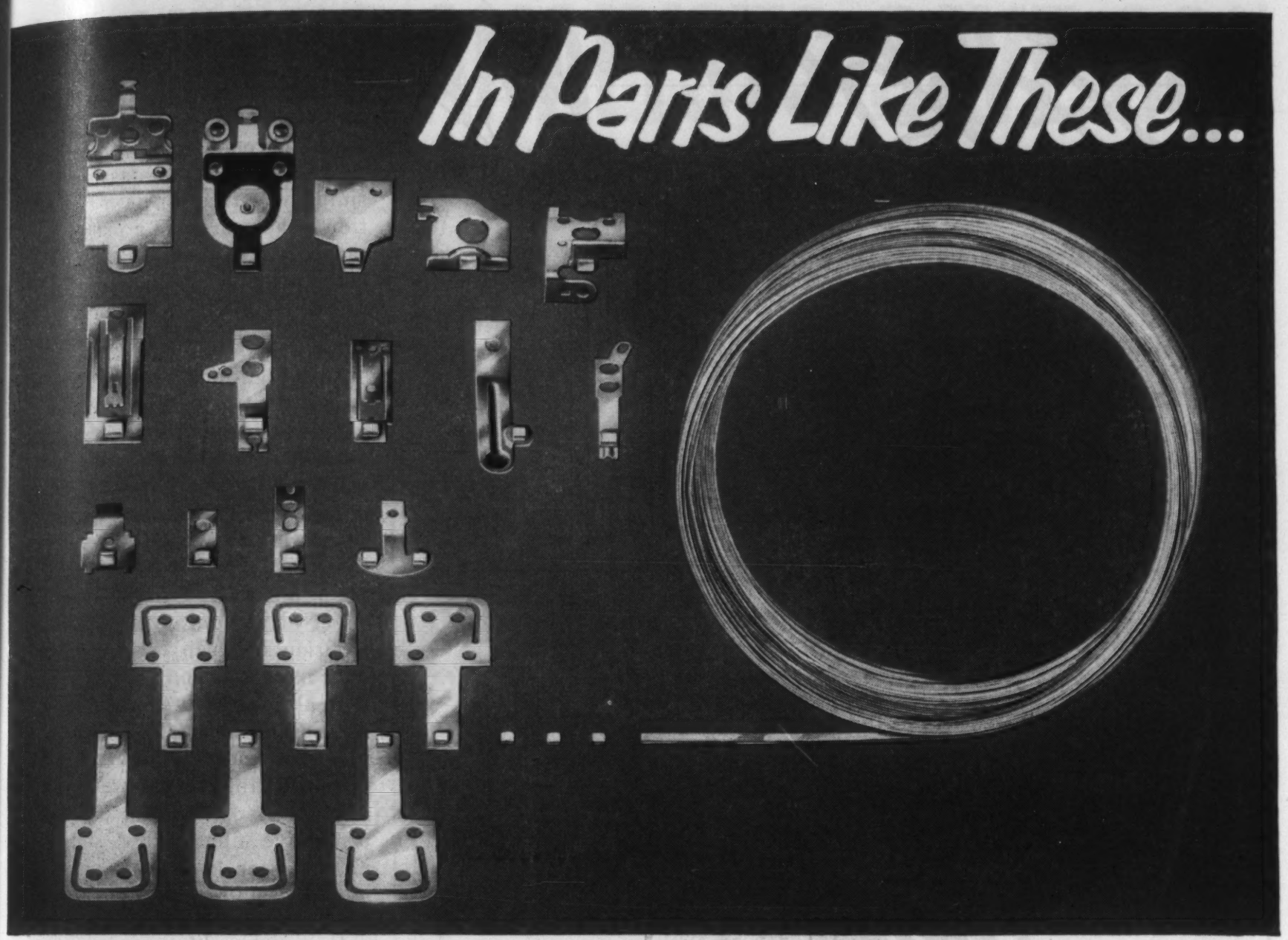
The intrinsic corrosion resistance of tin plate is usually great enough for ordinary applications, but it is known that staining occurs when tin plate containers are used for protein-containing foods such as meat and certain vegetables. During sterilization there is some decomposition of the food and liberation of sulfur compounds that may attack the tin and stain it to a blue or purple color. This stain is superficial and harmless, but its appearance may reduce confidence in the cleanliness of canned foods.

In exceptionally severe cases it is even possible for the steel itself to be attacked and ferrous sulfide formed. This is particularly objectionable, as the sulfide may become detached and contaminate the food.

Preventing staining

Both staining and rusting of tin plate can be prevented by applying a protective lacquer coating. Sulfur-resisting lacquers are frequently used inside cans to prevent blackening by protein-containing foods. Not quite as well known, however, are the chemical methods of protecting tin plate. Since the basic idea of chemical protection undoubtedly has its origin in the protection of aluminum by oxide films applied by chemical or electrochemical methods, it is not surprising that the earliest chemical methods of protecting tin plate relied on electrolytic treatment in aqueous electrolytes. Because of the intricate and costly machinery required, this method has not achieved any commercial success.

A chemically oxidized film, applied between fusion of the electrodeposited tin coating and final oiling of the strip, is widely used today because of its relative ease of application. Solutions vary from simple chromic acid or mixed chromic and phosphoric acids to alkaline chromates or al-



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kaline chromates and phosphates. Although some plants provide a simple chemical dip in a hot solution, others provide a preliminary cathodic treatment or alternating cathodic and anodic treatments in the oxidizing solution.

Simplified treatment

Investigations at the Tin Research Institute showed that the earlier solutions used were unnecessarily complicated and that it was possible to do without sodium phosphate. This is an immediate economic advantage as it removes the most expensive ingredient of the solution. Investigation of the effect of sodium chromate on the reaction between tin and sodium hydroxide solutions also disclosed that although very small amounts of sodium chromate act as a depolarizer and facilitate the dissolution of tin, greater amounts oxidize the surface and produce a protective film. Other oxidizing agents, such as sodium perborate and potassium permanganate, produce similar results.

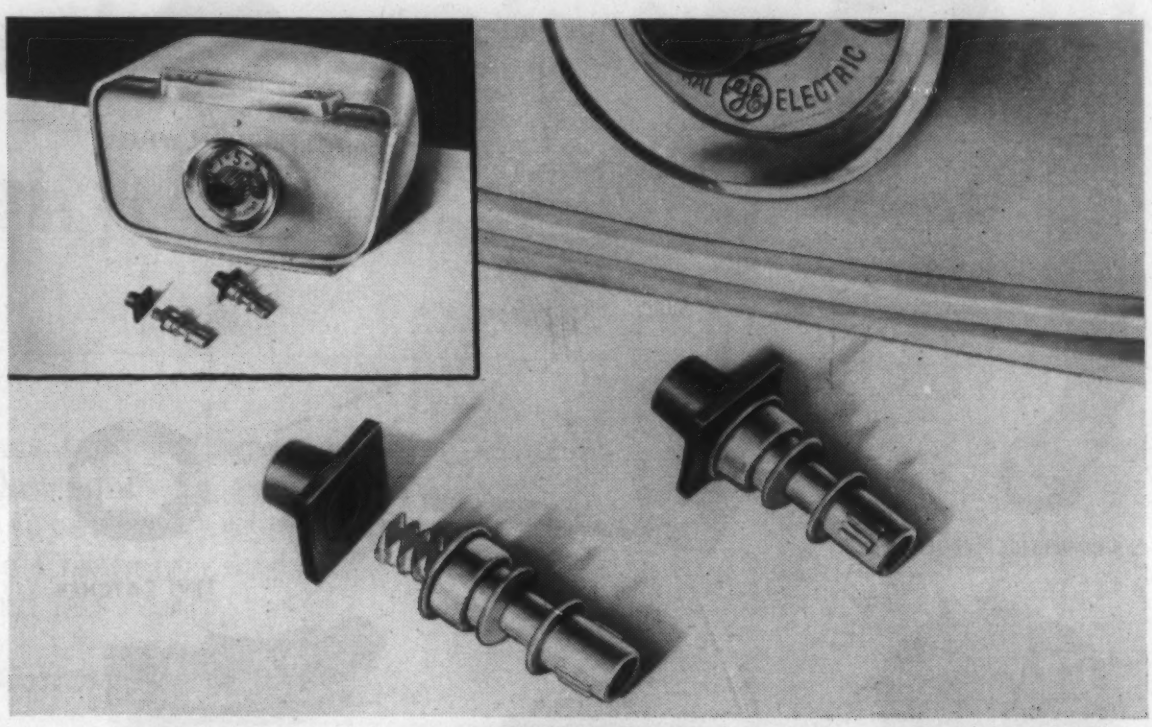
The treatment now recommended utilizes a solution containing 3 gm/l of sodium chromate and 10 gm/l of sodium hydroxide, to which is added 2 gm/l of a wetting agent, such as sodium alkyl sulfate, suitable for use in alkaline solutions. Exposure should be at temperatures of 194 to 203 F for 3 to 5 sec and should be followed by a hard water wash. This chemical treatment, when suitably applied, protects tin plate from blackening by sulfur-bearing products, delays the onset of rusting (although it cannot completely eliminate it), and provides a good base for a coating of lacquer or paint.

Nickel-Tungsten Alloys Have High Hot Strength

Nickel-tungsten alloys containing up to 40% tungsten, produced by powder metallurgy methods, can be cold worked into fine wire and strip suitable for electronic applications. These alloys have a

GE VALUE ANALYSTS SAVE 80%

COMBINE SMALL GRC ZINC DIE CAST AND MOLDED NYLON MATING PARTS



Gries molded nylon nut and zinc alloy die casting form mating units for GE electric blanket control part, at one-fifth the cost of the original expensive screw machine parts.

GENERAL ELECTRIC UTILIZES GRIES' INGENUITY: BUYS PARTS FOR ELECTRIC BLANKET CONTROL AT 1/5TH OF FORMER COST; GRIES TECHNIQUES ALSO IMPROVE PRODUCT'S BASIC DESIGN

Value Analysts at GE's Automatic Blanket Division consulted Gries Reproducer Corp. in an effort to lower cost and improve design of their manufactured products. One result: over 80% savings on the two intricate parts illustrated above now produced as zinc alloy die cast and molded Nylon mating parts.

Gries' exclusive techniques made it possible to die cast the threaded shaft—a former screw machine part—with threads, holes and metal-saving indentations as integral parts of the casting, delivered ready-for-use.

The GRC Nylon part, formerly a special screw-machine brass nut, is now molded in one integral piece with accurate, *molded,* internal threads.

The combination not only results in superior part performance but the overall savings on these two components is over 80%.

This is only one example of the many types of savings that Gries' unique methods are affording industries in the production of better and more economical small parts.

These examples illustrate how well GRC, as a single source of supply, can precisely "mate" parts, even of different matrials.

GRC again demonstrates its ability to supply industry with tiny parts at lower cost—with additional built-in economies and superior performance.

Informative Die Casting Bulletin Gives Examples, Facts from Gries

Gries' fact-filled die casting bulletin shows many examples of how GRC may help you solve your small parts problems.

It also tells about GRC's design engineering services for the solution of specific problems. Send for this bulletin today or, send prints for prompt quotations on quantities of 100,000 to many millions - completely trimmed, ready to use, precision made die cast parts. Smallness of Gries die castings is unlimited: maximum weight ½ oz., maximum length, 1¾ in.

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The infinite possibilities offered by Gries' methods in molding tiny plastic parts offer design engineers almost unlimited latitude in their designs.

GRC molds all thermoplastics—Nylon, Kel-F, acetates, polystyrene, polyethylene, etc., with Nylon a specialty. Maximum length 1¼"; maximum weight .03 oz; minimum unlimited.

A new bulletin is now available giving complete details of Gries Plastics Molding Division. Send for it today.

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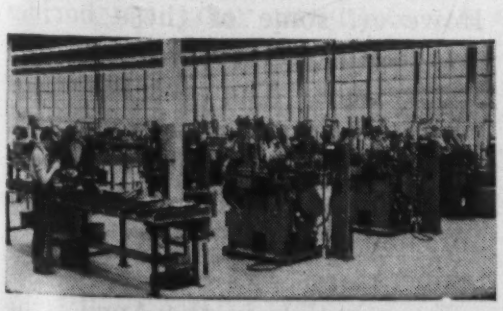
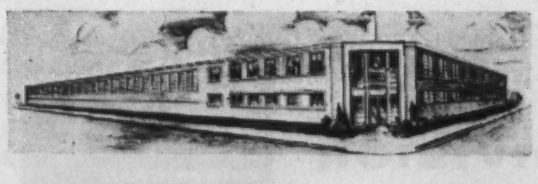


Included in the many facilities offered at the modern Gries plant are complete departments for performing secondary operations such as tapping, drilling, assembling, reaming, and special machining. Practically all commercial finishes can be applied in GRC's specialized plating department.



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Probably no single group of plastics offers design engineers such wide latitude in meeting specific service conditions as the Durez phenolics. These eight components now helping to implement the slogan "You can be sure if it's Westinghouse" are a notable example.

The problem was to create long-wearing, non-corrosive, economical parts of light weight for new Laundromats. All these objectives were achieved by replacing metal with parts molded of *four different* Durez materials. Working as a team, Westinghouse engineers and the molder, GENERAL INDUSTRIES CO., selected each of the four Durez phenolics for better performance at lower manufacturing cost on the job it must do.

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useful range of properties, particularly for cathode construction where a material having greater hot strength than pure nickel is desirable.

Production and properties of these alloys are described by M. Davis, of the Admiralty Services Electronics Laboratory, and C. E. Densem and J. H. Rendall, of the British National Physical Laboratory, in an article in the February issue of *The Journal of the Institute of Metals* (British). For exceptionally heavy duty, the 40% tungsten alloy offers outstanding advantages because it can be shaped in the annealed condition and age hardened in the 1300 to 1750 F range, a range that coincides closely with the operating range of oxide coated cathodes. Most requirements, however, can be met by alloys containing less than 30% tungsten, and these alloys can be fabricated more readily than the age hardenable materials.

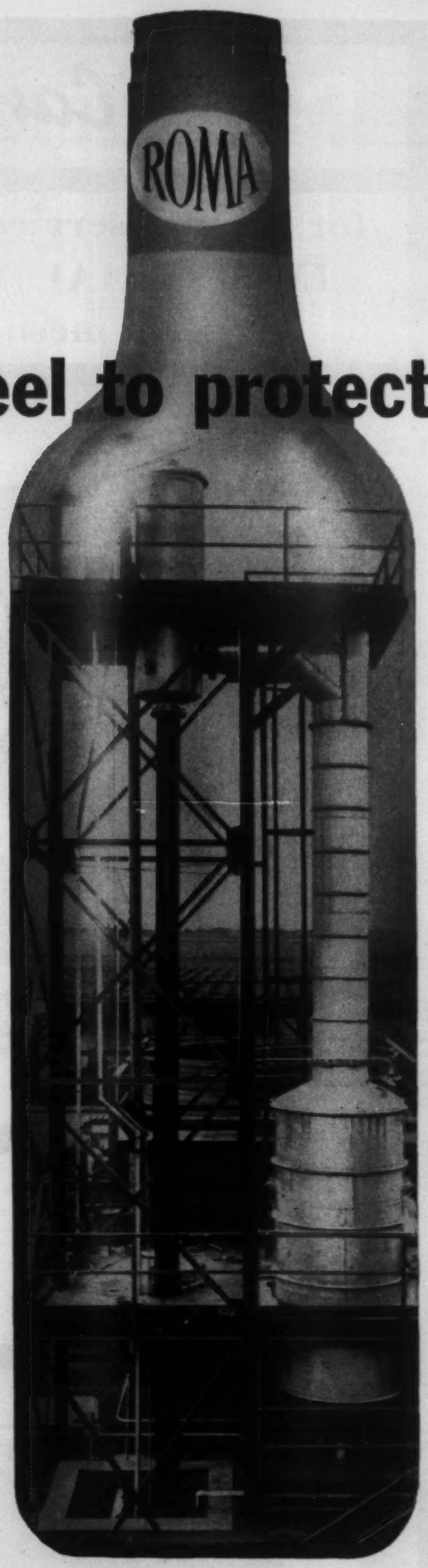
The alloys may be useful in other vacuum tube applications where their high strengths and high electrical resistivities, combined with nonmagnetic properties, make them a valuable addition to the limited number of alloys available.

Borides Resistant to Liquid Metals

Transition metal borides were developed in the search for materials for service at high temperatures in aircraft power plants. However, some of these borides are useful in more conventional applications. Their usefulness is based on their corrosion resistance, their high temperature stability in high vacuum and their abrasion resistance at elevated temperatures.

In an article in the April issue of *Powder Metallurgy Bulletin*, Arnold Blum and William Ivanick, of the Borolite Corp., discuss the resistance of two of these borides to liquid metals. Zirconium bor-

Designed with stainless steel to protect product purity



America's largest winery has specified stainless steel in new equipment, as a regular policy to replace old and obsolete installations known to be sources of metal pick-up. This user, The Roma Wine Company, finds prevention far better than the cure. And less costly, too!

Resist Corrosion

Chromium-nickel stainless steels resist attack by chemicals and atmospheres over wide ranges of concentrations, pressures and temperatures.

Prevents Contamination

The inherently hard, smooth surfaces of these austenitic chromium-nickel steels make poor harbors for bacteria or other contaminants.

Easy to Clean

Also, users find stainless steel equipment easy to clean and to *keep hygienically* clean as well as attractive in appearance.

New Stainless Steel Booklet Available

Write for a copy of "Stainless Steel in Product Design." Yours for the asking . . . it tells where and how to use stainless, how to design for lower cost, and other ways to give your products an edge on competition. Write for it now.

Roma Wine Company, a division of Schenley Industries, Inc., makes grape juice concentrate at the rate of 600 gallons per hour in the vacuum pans (above) of chromium-nickel stainless steel. Typical of other stainless equipment used for safeguarding purity of Roma products are pasteurizers, heat exchangers, centrifugal pumps, agitator tanks and wine coolers. All of austenitic chromium-nickel stainless steel.

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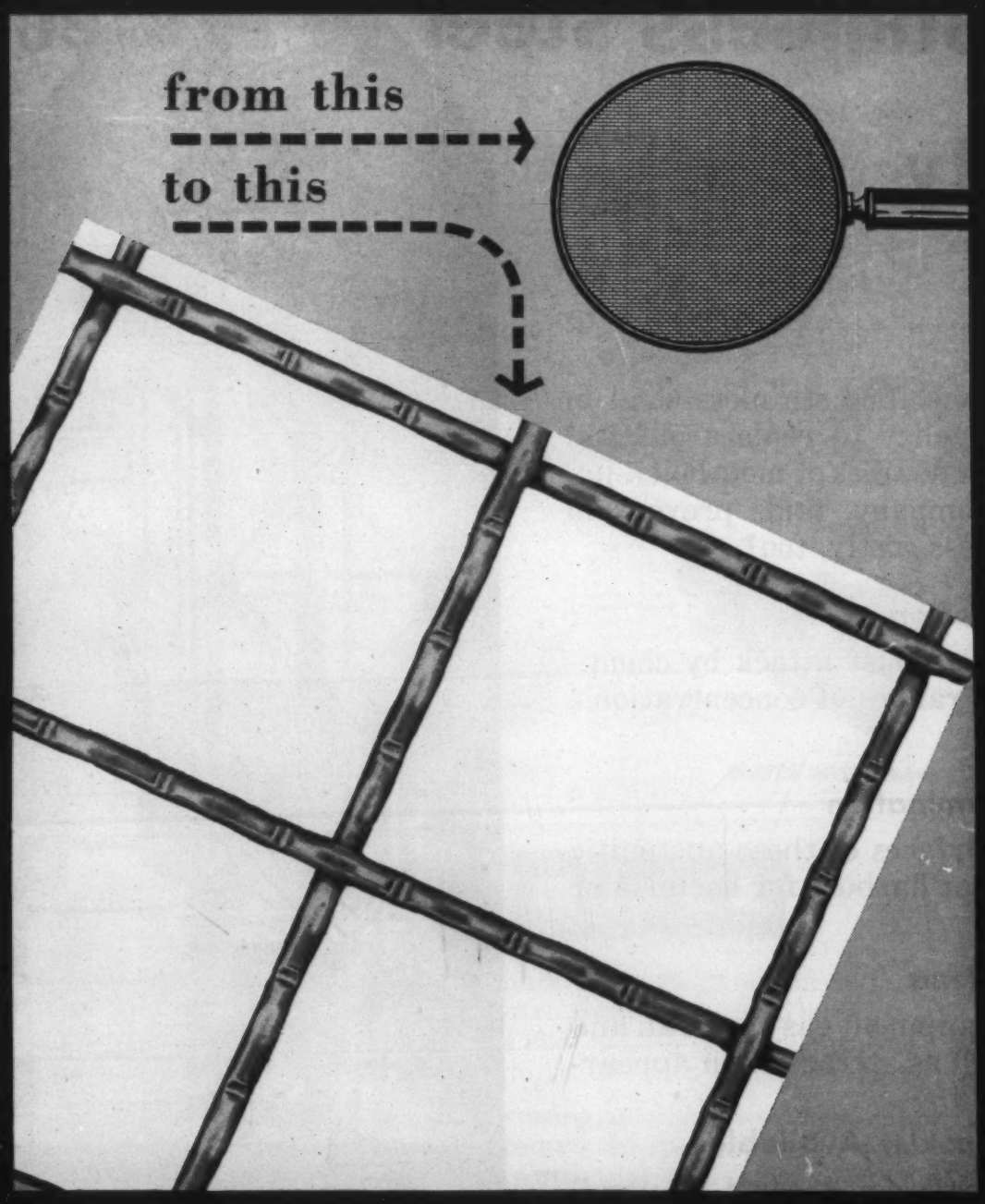

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ide is not attacked by molten aluminum, tin, copper and lead, and is only slightly attacked by molten low zinc brasses. In the form of protection tubes, zirconium boride has shown good resistance to liquid manganese, cobalt and steel.

Chromium borides bonded either with the transition metals or with iron alloys can be used as a coating to improve the resistance of base metals (not specified) to attack by molten metals.

New Insulations for Magnet Wire

Two new developments in magnet wire insulation hold considerable promise for improving the performance and life of electrical equipment operating in high temperature environments. Data on these insulation systems, one an epoxide-polyester enamel and the other a Dacron-fiberglass sleeving, were presented by Earl L. Smith, Ralph Hall and R. N. McKnight, of Phelps Dodge Copper Products Corp., at a meeting of the American Institute of Electrical Engineers in April at Fort Wayne, Ind.

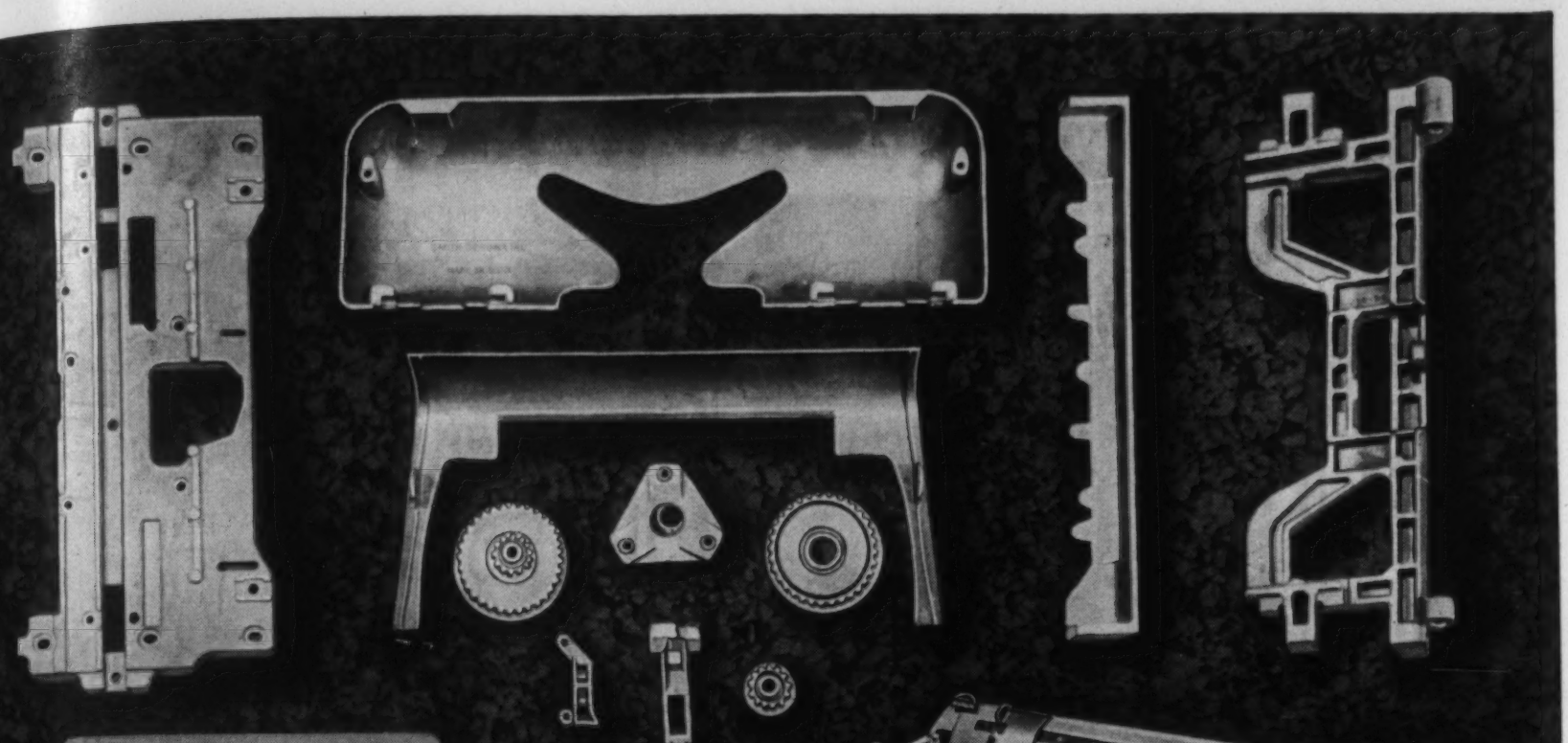
Epoxide-polyester enamel

Many formulations of epoxide resins have been suggested as coatings for magnet wire. Proprietary formulations that utilize a dibasic acid as the curing catalyst have been offered by various American, British and European firms. However, these varnishes have not gained general acceptance because of poor can stability, low solvent resistance and cut through, and a tendency to "dry craze."

An acceptable enamel for insulated magnet wire must possess the following characteristics:

1. It must be extremely stable and be capable of withstanding continued circulation, filtration and exposure to air.

2. Enamel batches must be reproducible and have the same viscosity, cure characteristics and



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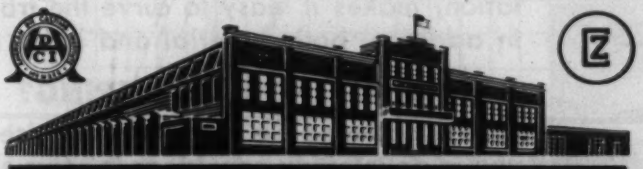
NOW!... 11 Die Cast Parts in Smith-Corona's New Electric!

Smith-Corona calls their newest Electric Typewriter "the fastest in the world." Other features they list as exclusive are "a cushioning action that eliminates all jar at the end of each keystroke"; "complete keyboard control, and a revolutionary new keyboard slope." Their aim is to make this machine the easiest to use of all electric typewriters.

Also interesting to note is Smith-Corona's increasing reliance on die casting. With the urgent need in the electric machine for intricate parts of great strength, rigidity, and high precision . . . the model shown here has no less than 11 die cast parts! These include top plate, keyboard guard, pulleys, pinion gear, and type bar segment mounting — all highly complex castings.

The more complex and manifold your production problems, the more natural — and profitable — it is to call upon Mt. Vernon. For as manufacturers in many fields have discovered, Mt. Vernon has the most complete die casting service — comprising coordinated designing, die-making, casting, and machining, all under one roof. We give you to the highest degree all the advantages of die casting: thin wall sections of great strength and rigidity, and parts produced to such close tolerances that often no machining is necessary. We have 162,000 square feet of the most modern equipment for making dies and for die casting aluminum and zinc.

It will pay you to bring your product specifications to us. We may show you, as we showed Smith-Corona, the way to important cost reductions and improved products.



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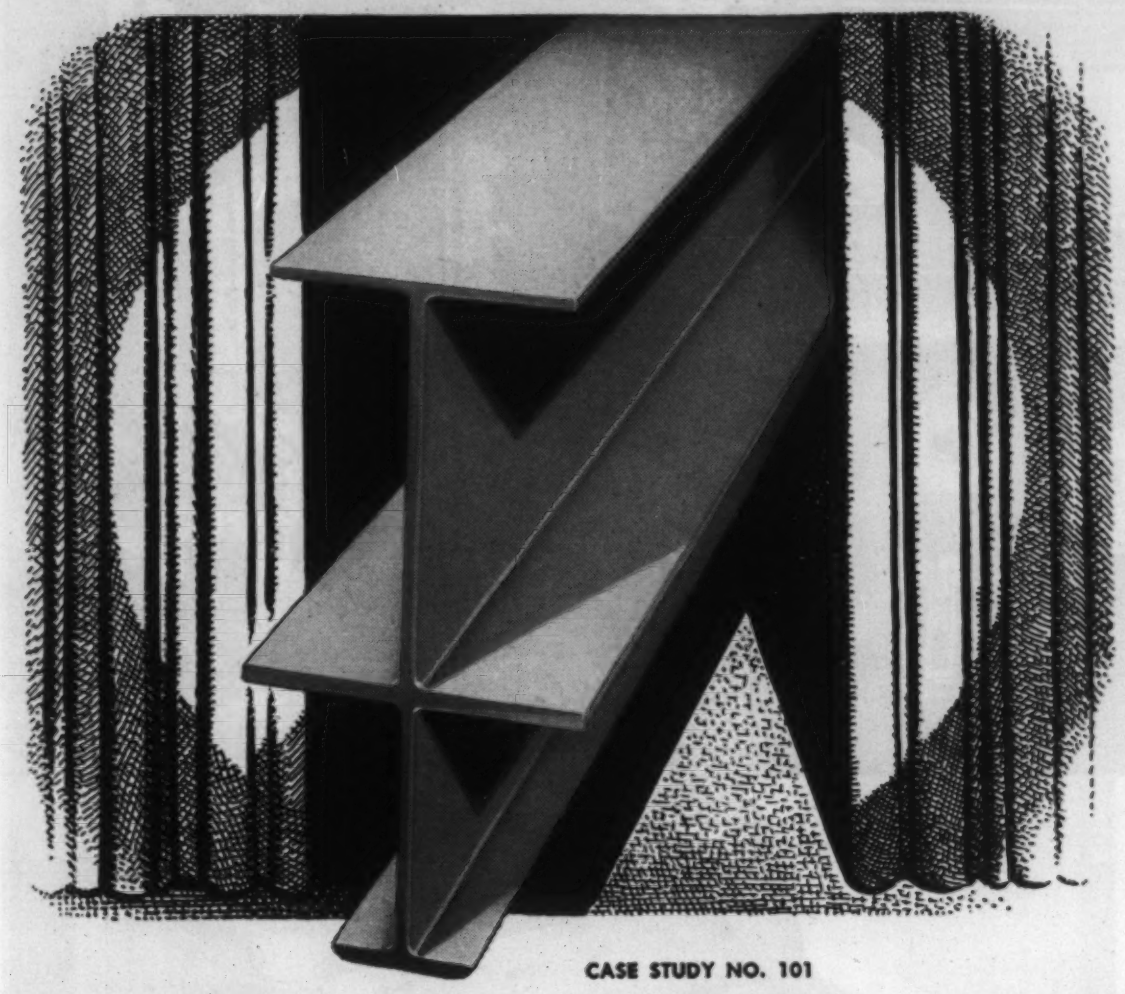
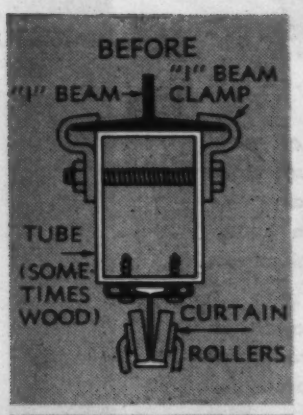
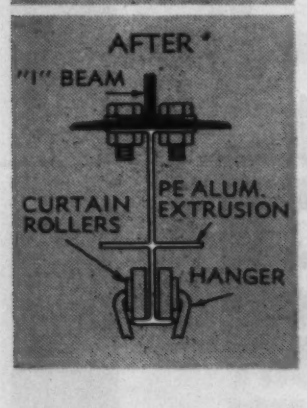
Art Drapery Studios rate repeated curtain calls



CASE STUDY NO. 101

HOW PE EXTRUSIONEERING* CUT TRACK COSTS 50%





Art Drapery Studios, 2739 N. Racine Ave., Chicagoland designers and installers of stage curtains and gymnasium dividers, had a track problem—and tracks are an important part of any job they do. Over-all costs were high because of drilling, assembling, splicing, and installation operations.

THE PROBLEM AND SOLUTION

Could Precision Extrusions, Inc. design a one-piece extruded aluminum track that would solve these problems? As illustrated, PE engineered a track that eliminates drilling, assembling, and splicing operations; simplifies installation; makes it easy to curve the track right on the job. In addition, both material and labor costs are cut 50%.

* WHAT IS EXTRUSIONEERING?

"Extrusioneering" is a PE *plus* service designed to assist you in developing new ideas to solve specific problems, to cut manufacturing costs, and to improve product quality.

Most likely your need is far removed from curtain tracks; but why not call in a PE engineer and let him work with you towards a solution to *your* problem—whatever it is. There is no obligation.

PRECISION EXTRUSIONS, INC.

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flow properties.

3. The enamel must be suitable for application to a complete range of wire sizes, Nos. 8 through 44 AWG.

4. The enamel films must be chemically compatible with the many types of materials, varnishes and compounds with which the wire may come into contact.

5. Since many motor failures are due to short circuits resulting from exposure of the wire enamel to heat and pressure, the enamel must have a high cut through temperature.

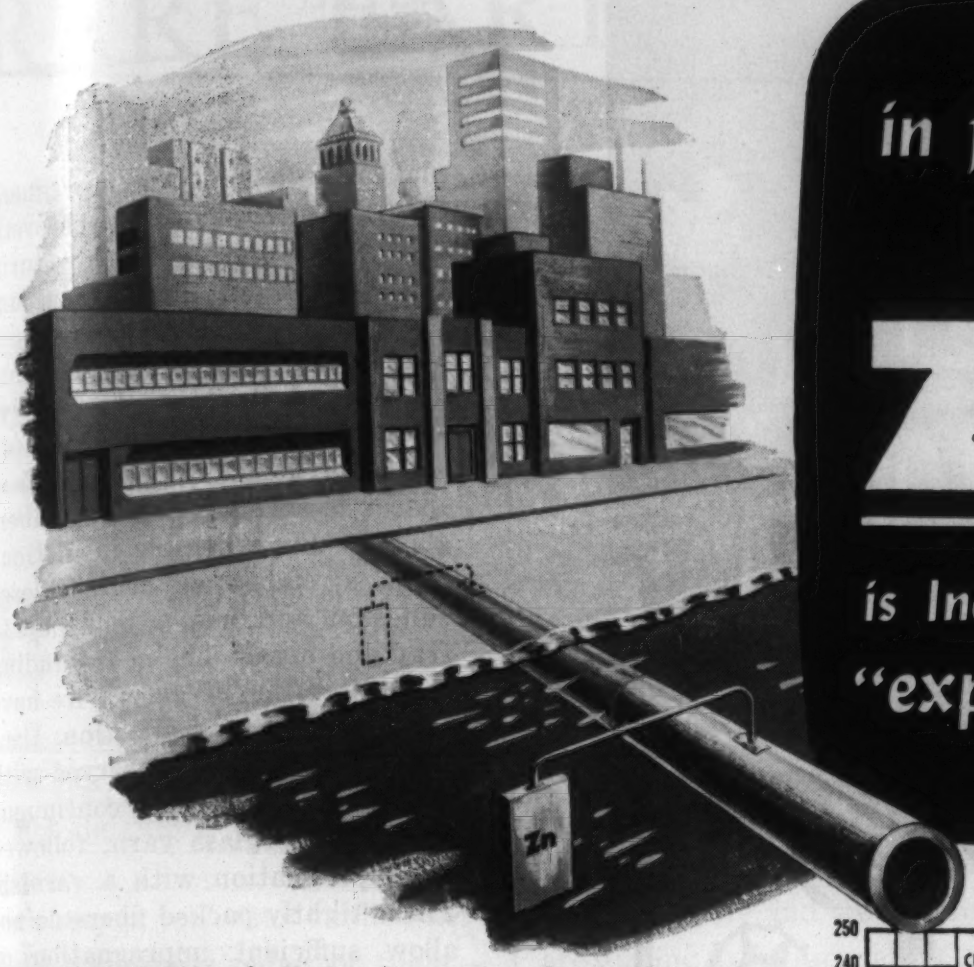
6. The enamel must have good aging properties at high temperatures.

After intensive study of various epoxide varnishes, one formulation appears to offer the most promise. Called Thermaleze, this coating is made up of an epoxide resin, a heat resistant polyester resin and a curing agent. The varnish is stable indefinitely and cures rapidly at enameling temperatures.

Compared to other available insulating films, the epoxide-polyester film possesses better flexibility life, greater retention of dielectric strength upon aging at high temperatures, as well as a substantially higher cut through temperature. The excellent chemical compatibility of the epoxide-polyester film, stemming from its epoxide base, enables it to be used with most varnishes and insulating materials, whether they be phenolic, epoxide, polyester, silicone or cellulosic in nature. This mutual compatibility with many materials enables Thermaleze to replace conventional Class A film-insulated magnet wire in existing designs where a greater safety factor is desired.

Dacron-glass insulation

Continuous filament fiberglass insulation, impregnated with an appropriate varnish, has been used for a number of years at Class B and Class H temperatures. Ideally, fiberglass provides a positive inorganic spacer between turns. Even when extensive ther-



in fighting corrosion with corrosion—

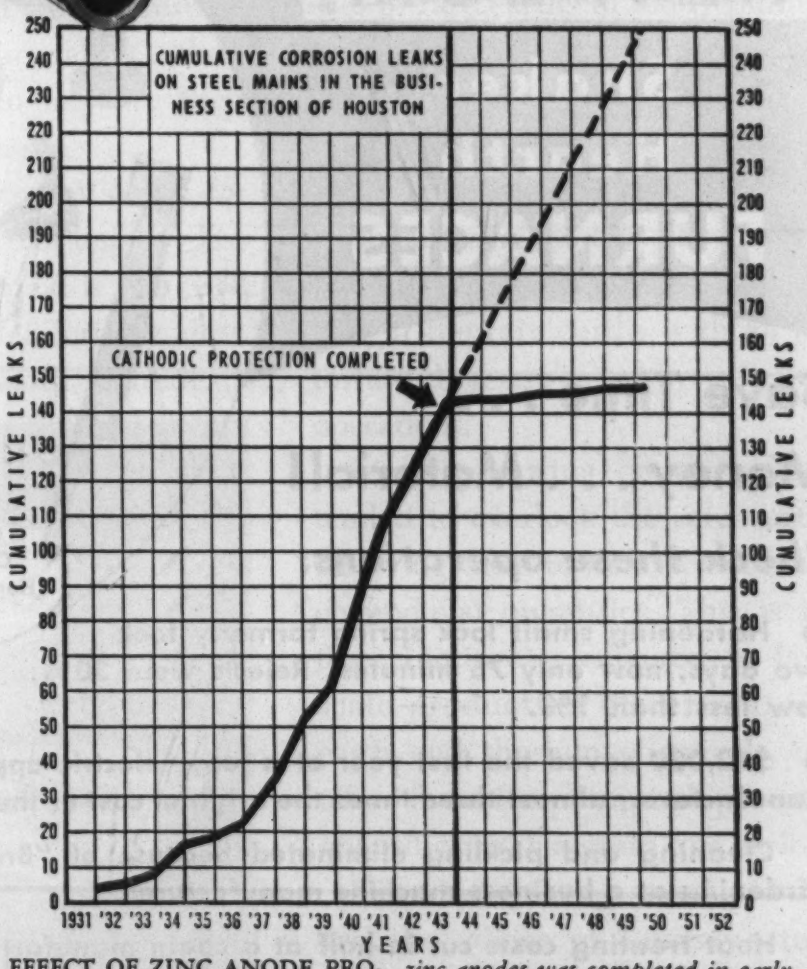
ZINC

is Industry's most effective "expendable" weapon!

NEARLY 50% of all the zinc consumed annually in the United States — around 400,000 tons — is used in galvanizing, i.e., protective zinc coating on iron or steel. This is ample evidence of the metal's firmly established position as industry's most effective and economical "sacrificial" weapon in its unceasing combat with rust. The electrochemical reaction between iron and zinc in galvanizing is precisely the same as that which takes place in the relatively new and growing use of zinc for cathodic protection of pipe lines and other underground iron and steel structures. The sole difference between the two methods being that in cathodic protection the zinc, in the form of anodes, is buried adjacent to a pipe line and connected by a conductor, while in galvanizing the zinc is bonded to iron or steel. In either form, zinc "protects"— as has been attested to by those progressive companies who have used zinc anodes for this purpose. For example in the northwest, a utility company reports:

> *"The most interesting installation was made in 1942 on four inch bare pipe located in the seepage from an irrigation ditch that circled the brow of a hill in such a manner that the pipeline trench intersecting the irrigation ditch was kept moist throughout the season. Approximately seven hundred feet of this four inch line had been replaced twice. In the spring of 1942 leakage developed and when the pipe was uncovered it was found to be in bad condition. Pending replacement, repairs were made and seventeen zinc anodes were installed with series-parallel connections. In the press of other work, this replacement job was put aside and in 1943 it was found that no further leaks had developed. In 1948 the replacement had still not been made and we were getting a good potential-to-ground and plenty of protective current. The last test made in the spring of 1950 shows a slight increase in the potential-to-ground and the pipe has not been replaced nor have we felt it even necessary to uncover it for visual inspection."*

The graph at right provides additional evidence from the State of Texas. Here are two examples, under widely dissimilar conditions, where zinc has proved itself as a highly efficient cathodic protector for underground pipe lines. This is not surprising in view of the long-recognized superiority of the metal in the field of galvanizing.



EFFECT OF ZINC ANODE PROTECTION ON OLD LINES. *Most of the United Gas Corp.'s welded-steel-gas distribution mains, coated with hot asphalt and asbestos wrapper, were installed before 1930. Cathodic protection of mains with zinc anodes was completed in early 1944. Curve shows cumulative leak record of these mains. Only 5 corrosion leaks occurred in the 6 years since cathodic protection was applied, comparing with 142 during 1932-1944.*

52 PAGES OF NEW DATA

For complete details on this application of zinc, write for free booklet, CATHODIC PROTECTION WITH ZINC ANODES

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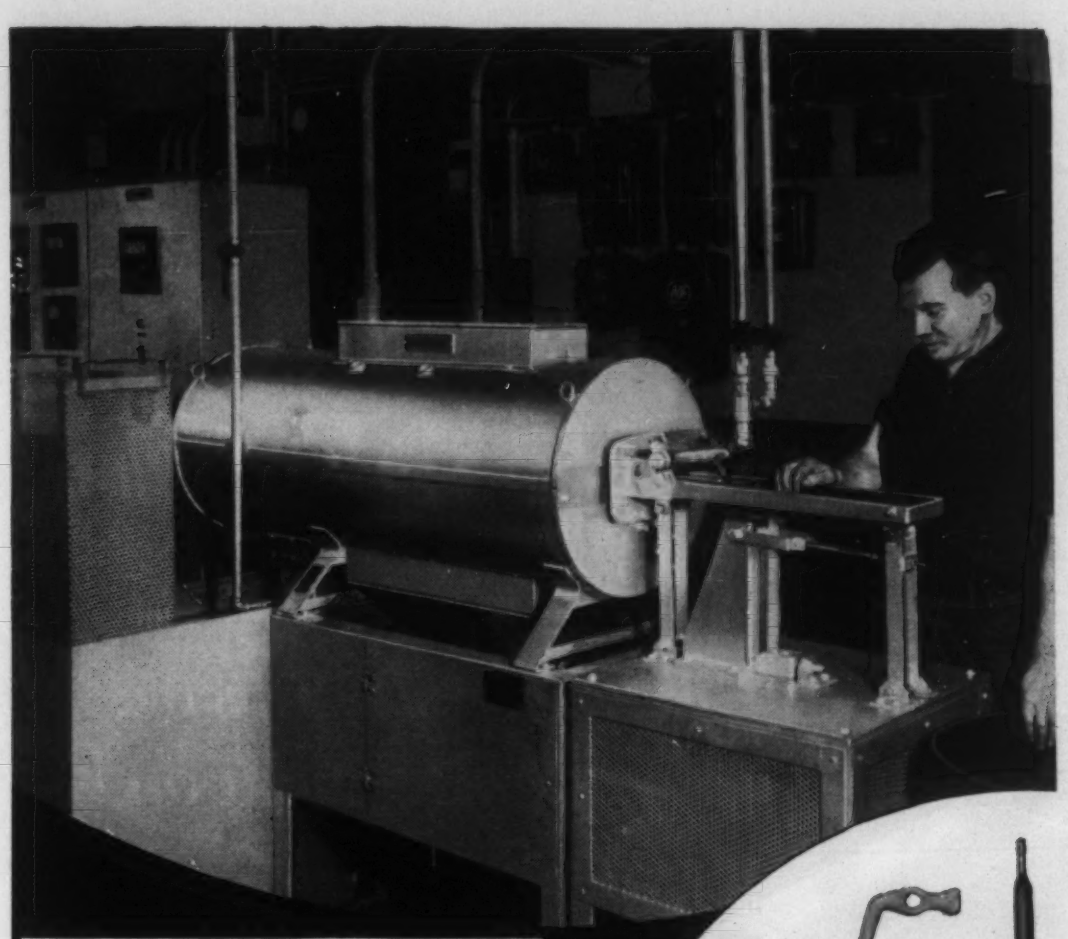

·HEVI DUTY·

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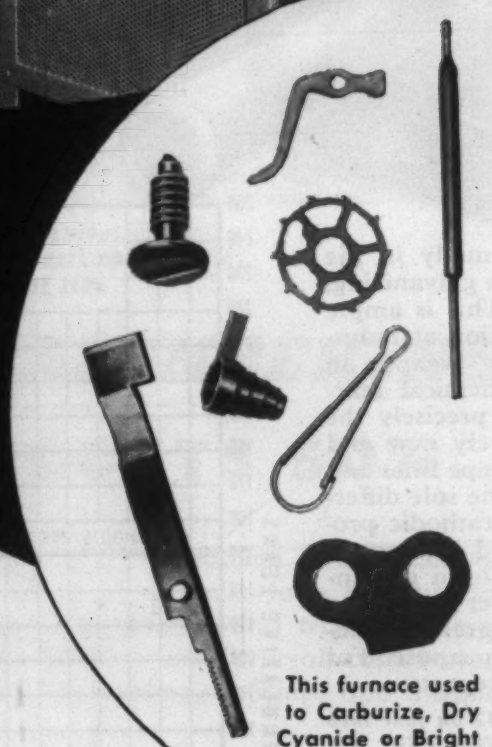

This furnace used to Carburize, Dry Cyanide or Bright Harden these parts.

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- **Cleaning and pickling eliminated because of "Bright" case hardening at a business machine manufacturer.**
- **Heat treating costs cut in half at a chain manufacturer due to the ease of operation.**
- **Stainless steel springs "Bright" hardened without distortion because the parts are individually heated in a protective atmosphere and then are dropped directly into the oil quench.**

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mal breakdown of the impregnant occurs, direct shorts are theoretically impossible at the low turn-to-turn voltages normally encountered. However, because of poor adhesion of fiberglass to the conductor and its poor abrasion resistance and flexibility, the problem of breaks in the organic glass spacer is serious. Basically, fiberglass is not a flexible insulation; when stretched or bent it loses adhesion and has a tendency to fray and break. The poor winding characteristics of glass wire have also limited its application. Usually, the wire is first served with one or more layers of continuous filament fiberglass yarn, followed by impregnation with a varnish. These tightly packed fibers do not allow sufficient impregnation of the varnish and prevent the formation of a good bond.

Recently, however, it has been found that by serving a combination yarn of Dacron and fiberglass on the wire and subsequently fusing the Dacron portion, it is possible to obtain a remakably adherent, flexible, abrasion resistant and thermally stable insulation. Known as Daglas, the insulation is formed by plying together fiberglass and Dacron yarns. The composite yarn, containing from 30 to 45% Dacron, retains the positive inorganic spacing afforded by the fiberglass and provides the physical properties to withstand winding stresses.

Daglas wire has approximately eight to ten times the abrasion resistance of conventional glass wire. Also, adhesion to the conductor is not lost when the wire is stretched to its breaking point. Conventional wire generally loses adhesion after only a few percent elongation.

Dacron, which is a condensation polymer of terephthalic acid and ethylene glycol, has excellent thermal stability. At temperatures up to 392 F it does not carbonize or powder. Normally, its use at elevated temperatures has been limited because of plastic flow. However, since fiberglass is the domi-

RARE EARTHS AS CATALYSTS

An application which offers intriguing possibilities

a report by LINDSAY

EVER tried to burn a cube of sugar? It can't be done, you know—unless you use a catalyst . . . in this case cigarette ashes. Dust the cube with ashes, apply a match and presto—you have a junior inferno.

Of course, you're not vitally interested in burning cubes of sugar—aside from amazing your non-technical friends. We mention this little experiment to focus attention on the use of rare earths as catalysts.

Cerium and cerium oxide are being used for this purpose in several industries. And it is highly probable that among the other rare earths, you will find some that have important commercial possibilities in your operations.

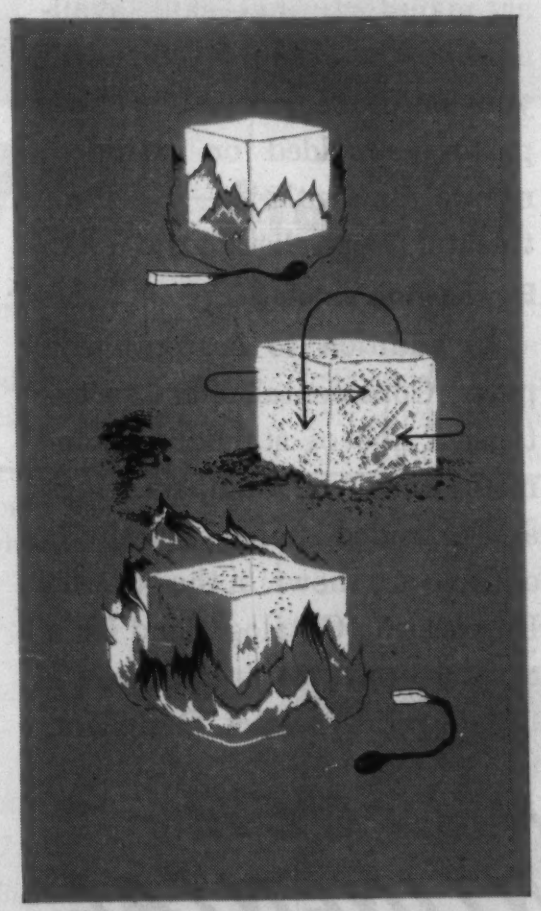
Interest in the rare earths as catalysts is gaining momentum. Although we, at Lindsay, do not make catalysts ourselves, we do supply rare earth materials for this use. Here are some of the operations where rare earths may have a place in your industry. *Ammonia Synthesis and Oxidation, Combustion and Oxidation, Dehydration, Dehydrogenation and Hydrogenation, Fischer-Tropsch Reaction, Halogenation, Methanol Synthesis, Polymerization, Crude Oil Cracking, Paint Driers.*

If any of these processes play a part in your plant operations, you may find it richly rewarding to investigate rare earths as catalysts.

This is only one of the many, many applications of these unique metals. Here at Lindsay, we have been refining and developing rare earths for over 50 years and almost every day we hear of new uses for them. Scientists in more and more industries are turning to the rare earths in their search for ways to improve their products and processes.

Take Lindsay's cerium oxide, for example. It has revolutionized glass polishing practices and is also used in colorizing and decolorizing glass.

Lindsay's rare earth chloride (a natural mixture of the chlorides of cerium, lanthanum, neodymium and praseodymium and some other rare earths) is used extensively in the textile industry, the metal industry and in the manufacture of paint and ink.



You'd be surprised at the diverse uses of rare earths in today's industrial technology. It seems as if every time you turn around, some researcher has found a new and practical application for one or more of these amazing metals. That's why we would like to suggest that you look at the rare earths with an eye toward their use as catalysts in your operations.

Some technical people have tended to overlook the rare earths, believing them to be unavailable in commercial quantities. This is not true. Lindsay is engaged in large scale production of cerium, rare earth and thorium chemicals, and offers them for prompt shipment in quantities from a gram to a carload.

To aid you, the accumulated data and the advice of Lindsay's technical staff is at your service. Your inquiry is invited.

PLEASE ADDRESS INQUIRIES TO: LINDSAY CHEMICAL COMPANY

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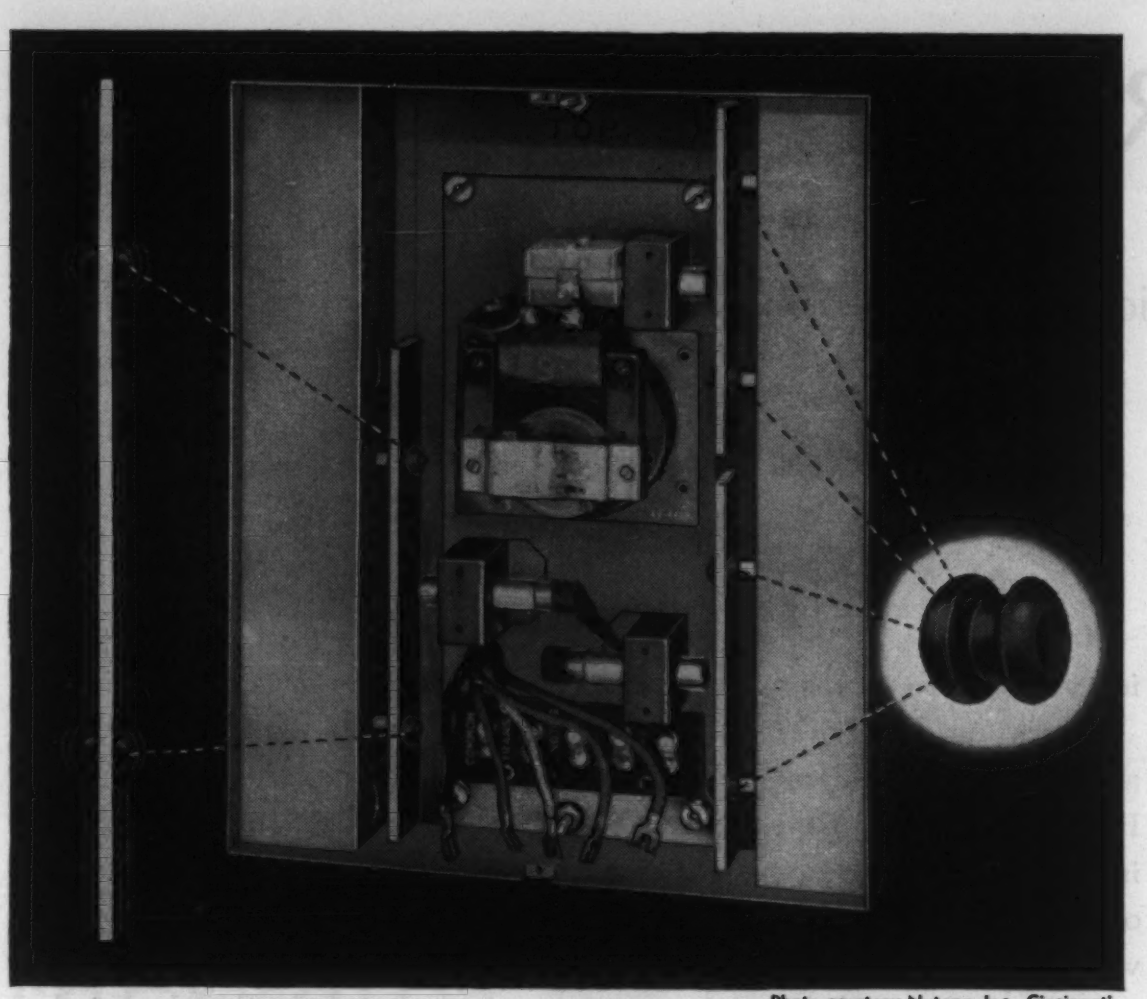

Photo courtesy Nutone, Inc., Cincinnati

Engineers Develop New Use for Rubber

Rubber, normally used to *reduce* vibration, now can be made to *increase* vibration

Here rubber grommets serve as mountings for the tone bars in Nutone Door Chimes. To obtain maximum tone quality and resonance required of these musical chimes, the grommets must vibrate compatibly with the tone bars . . . a truly *unusual assignment* for rubber.

Only by skillful compounding can rubber be diverted from its normal dampening characteristic and be given this vibrant quality. The slightest deadening effect would destroy the rich tones and kill the tone hang.

The successful development of this lively, age-resistant rubber stock typifies the complete engineering and laboratory—as well as manufacturing—skill available at Continental. Whenever you need "engineered rubber parts" — molded or extruded, natural or synthetic—call Continental, Specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
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nant spacing material in the Daglas insulation, some plastic flow of the Dacron bonding agent is permissible.

Test results indicate that the thermal properties of Dacron-fiberglass insulation are at least equivalent to those of fiberglass insulation containing an organic silicone varnish surface coat or impregnant. When covered with a modified silicone varnish, wire insulated with Daglas will perform as well as fiberglass-insulated wire at the Class H hottest spot temperature of 356 F.

Typical applications for Daglas wire include mill motor armatures, torroidal windings, traction motors, and aircraft generator stators and alternator armatures. In all applications the Daglas wire has proved quite successful as a direct replacement for fiberglass-insulated wire in long-life equipment operating at normal temperatures and in short-life equipment operating at high temperatures.

Plaster Molds for Magnesium Castings

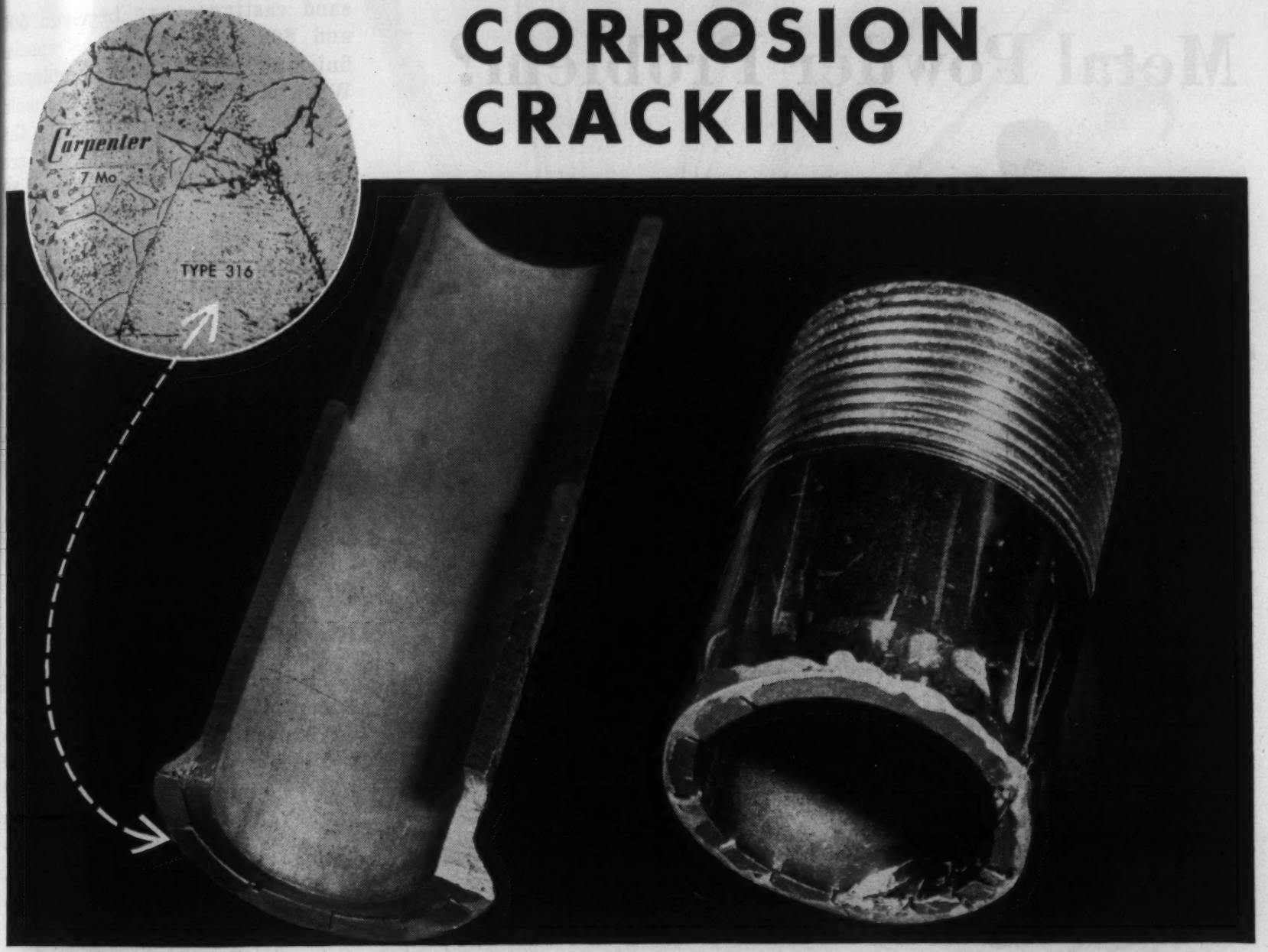
Closer tolerances, smoother surfaces and reduced costs have been achieved by using plaster molds instead of sand to produce magnesium castings. In a paper presented at the annual meeting of The Magnesium Assn. last fall, E. J. Willis, of the Aluminum Co. of America, concludes that plaster molds will continue to find application where normal sand castings can never hope to compete.

From an economic standpoint, plaster mold castings are considerably more expensive than green sand and should be used only where the specific advantages of the plaster process are important. These advantages include the ability to produce detailed lettering or markings on castings, local smoothness for air or oil flow, and close dimensional tolerances to reduce machining or hand finishing.

Surface finishes on magnesium

For cost-saving control of...

STRESS CORROSION CRACKING



Carpenter 7Mo Stainless Tubing & Pipe

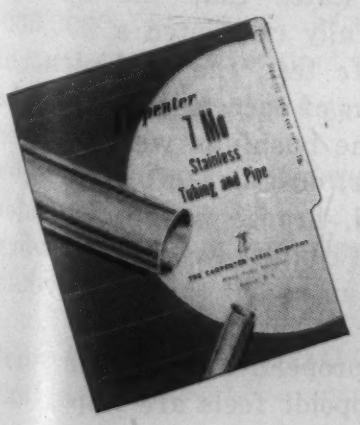
Take a closer look at the above section of Carpenter 7Mo Stainless Pipe welded to a Type 316 fitting. See how stress corrosion cracking has ruined the fitting, just as it has destroyed the piece of stainless pipe at right.

Note how the cracks in the fitting stop abruptly when they reach the 7Mo pipe. And this pipe has already outlasted three such fittings. The photomicrograph shows the unmistakable proof.

If you have conditions where chlorides, caustic or sulphite solutions are present, Carpenter 7Mo's excellent resistance to general corrosion, pitting and stress corrosion cracking may prove to be a real cost-saver. Let's discuss your particular application now.

The Carpenter Steel Company
Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"



Write for this Carpenter 7Mo Technical Bulletin.

Carpenter
more than corrosion resistance
Stainless Tubing & Pipe

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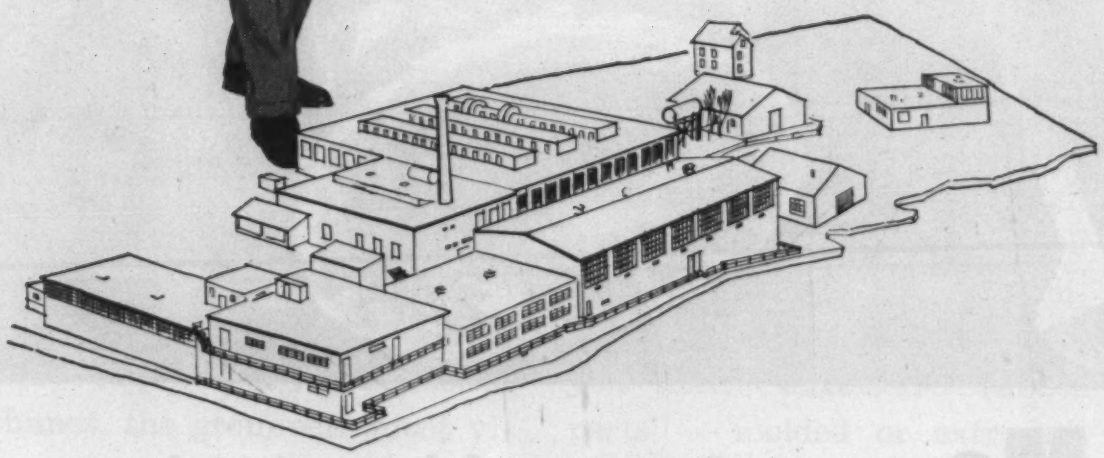

Serving American Industry since 1937, Metal Hydrides continues to pioneer in the production of new and unusual metal alloys in powder form. Through research and production experimentation, Metal Hydrides has developed a method for the manufacture of metal and alloy powders with unique physical properties . . . for a broad range of applications.

If you are concerned with a metal powder problem, consider this your invitation to meet Metal Hydrides. Your letter, wire or phone call will bring all the information required to really get acquainted.

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sand castings vary between 500 and 800 microin. unless special finishing techniques are employed. When plaster is used as the mold material, surface finishes in the neighborhood of 100 microin. are common, and finishes as low as 50 or 60 microin. have been found in some areas on the castings.

So far, there is no apparent size or weight limitation imposed when using plaster molds. Castings weighing from 1 oz to 100 lb have been produced with dimensions from 1 in. to over 3 ft. There is every indication that the plaster technique can be used for even larger castings.

Present Uses of Teflon Plastic

The first mechanical use of Teflon in an automobile is in a wrap-around bushing in the clutch lever assembly in the 1955 and 1956 Mercury. The Teflon-coated glass fabric bushing replaces a bronze bushing which was lubricated through a grease fitting. Principal difficulties with the previous design were: 1) the bushing was near the exhaust pipe, where heat could destroy the lubricant, and 2) the grease fitting was practically inaccessible. The Teflon-glass bushing eliminated these problems, since Teflon requires no lubricant and will withstand the temperatures encountered.

Bearing performance

As to service life of the bearing, Dr. W. B. Happoldt of Du Pont, writing in *Du Pont Magazine*, quotes a report by Ford which states that the bushing successfully completed a 300,000-cycle life test, the equivalent of ten years of operation. During the tests, the bushings were exposed to water, dust and oil. According to Ford, bronze bushings under the same conditions would be worn to such an extent that they would be noisy in operation.

The properties of Teflon that Dr. Happoldt feels are important

Basic shapes from Angles to Zees, and specialized shapes for architectural trim and truck bodies are available from stock in the principal corrosion resistant alloys. Many an odd or unusual shape is a stock item, too, since more and more companies have redesigned their small parts to capitalize on the savings in machining afforded by using preformed shapes.

Shot? We specialize in that, too—stocking foundry alloys, and making shipments in quantities from handfuls to carloads in Nickel, Silico-Manganese, Iron Foundry Inoculants, Vanadium, Chromium, Silicon, Titanium, Manganese for foundry corrosion resistant alloying purposes.

Whether it be shapes, shot, or anything else, selecting the one right kind of material in the corrosion resistant field is important. Recognizing this we're ready to advise you, since we stock all the principal alloys, we can and do give unbiased opinion.

So, when you need anything in the corrosion resistant line, think of Whitehead. Seven conveniently located warehouses with more than 20,000 items to choose from — products of such leading producers as Alcoa, Inco, Anaconda, Vancoram, and many others. You'll find it will pay to Call WHITEHEAD first.

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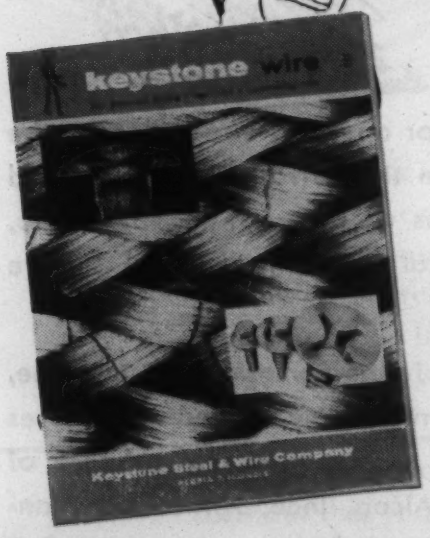

Keystone Steel & Wire Company
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Please send me the new booklet on Cold Heading Wire. A13

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to its mechanical and chemical life are its: 620 F melting point, the highest of any of the thermoplastics; excellent toughness at temperatures as low as —400 F; inertness to solvent and almost all corrosive chemicals; low water absorption; and low coefficient of friction.

Applications

How are these properties put to work by industry? A list of current applications includes:

1. *Gaskets*—Inert to chemical attack and corrosion, Teflon insures reliable, safe operation and low maintenance. Unless mechanically damaged, gaskets can be expected to outlast the equipment.

2. *Valve and pump packings*—Made of Teflon, they resist chemicals and high temperature and do not contaminate the process streams.

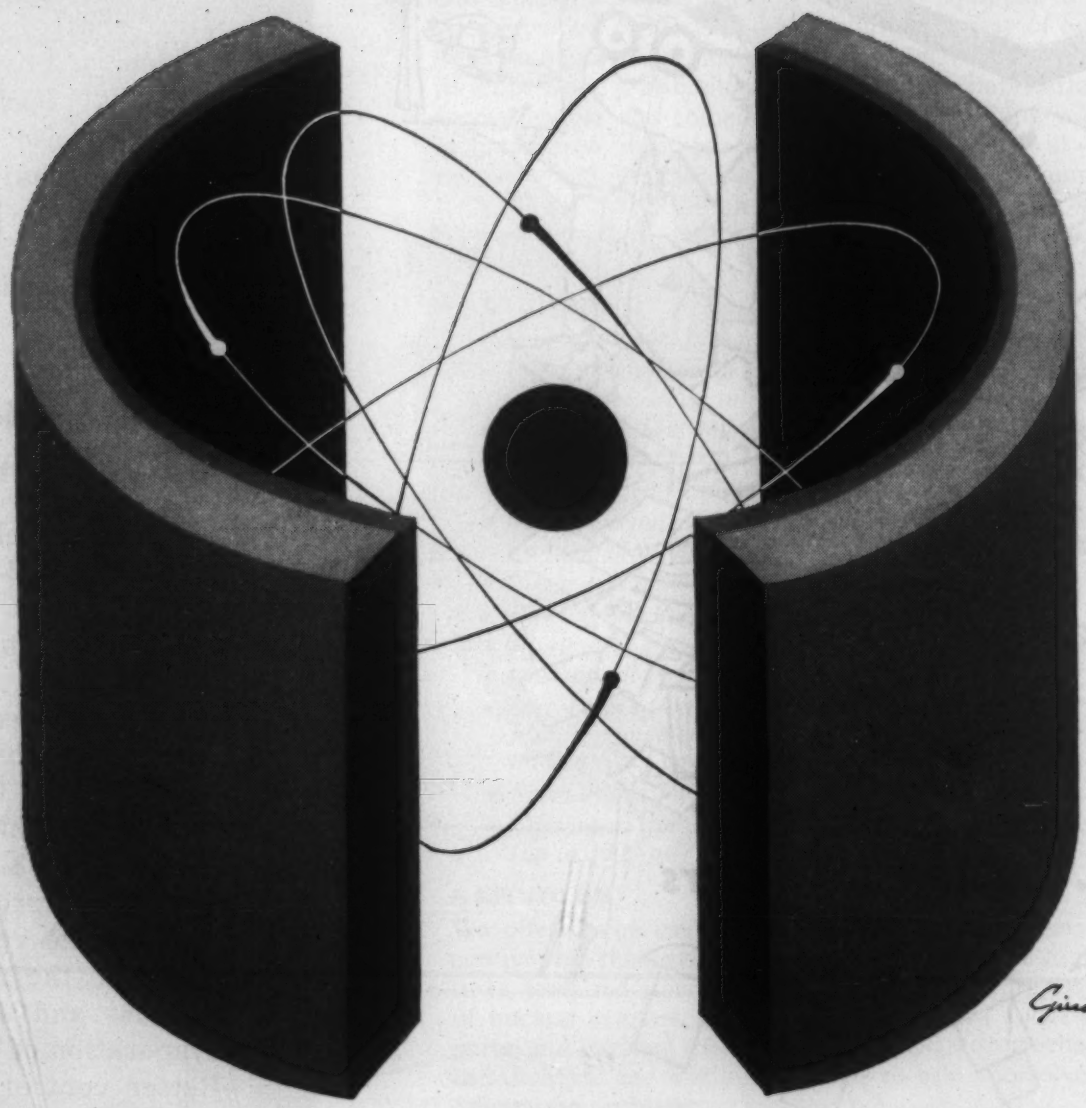
3. *Shaft seals*—Seals have been used on shafts turning at speeds as high as 3600 rpm.

4. *Diaphragms*—Since there is no plasticizer in Teflon, diaphragms do not become brittle in service. They are flexible and resistant to acids, alkalies and oxidizing agents.

5. *Pump impellers*—Operating continuously at —140 to 212 F, impellers are not damaged by hard particles in the process stream. Such particles embed themselves in the plastic.

6. *Valve liners*—Here the low coefficient of friction is important. Plug cock valves have to be pulled tight to hold high pressures, increasing the torque needed to open the valve. With Teflon liners, plugs can be turned easily.

7. *Bearings*—Both sleeve and saddle type bearings depend on Teflon's low friction coefficient for a bearing that never has to be oiled. Two other types of bearings depend on the plastic's ability to transmit a thin coating of itself to a metal. One is a ball type in which every other metal ball has been replaced by a ball of Teflon. Enough of the polymer transfers to the races to lubricate the metal balls, increasing service life. This



CLAD STEEL HOUSE FOR THE PEACEFUL ATOM

■ In the reactor shell of the first peacetime atomic power plant, the controlled fury of the fissioned atom will soon go to work—behind walls of Lukens stainless-clad steel. Involved in this huge project at Shippingport, Pa., are construction techniques without precedent which draw heavily on the equipment builder's vast fund of engineering skill and knowledge.

From Lukens, such builders get the kind of cooperation they like: specialized service as well as specialty steel plate. In clad steels, for example, they have a selection of 16 cladding and 11 backing metals—the widest range of types and sizes available. There's full information on clad steels in Bulletin 817. Write Manager, Marketing Service, 850 Lukens Building.

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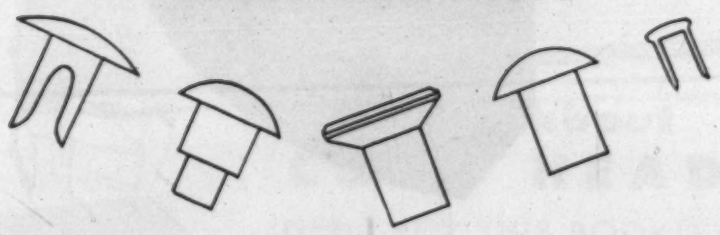

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same increased service life is achieved in unlubricated phenolic sleeve bearings when a strip of solid Teflon is embedded across the bearing face so that the rotating shaft can coat itself with Teflon.

8. *O-, back-up and scraper rings*—These parts are made of Teflon primarily because of the plastic's excellent resistance to heat and to the solvent action of the newer hydraulic fluids.

Nickel Alloys Upgraded by Vacuum Melting

Vacuum melting can produce a cleaner metal than can be produced by air melting, and composition can be more closely controlled. In a paper delivered at the annual meeting of the American Society of Mechanical Engineers in Nov 1955, F. N. Damara and J. S. Huntington, of Utica Drop Forge & Tool Corp., attribute the improvement in cleanliness to the removal of dissolved gases, to the reduction of oxides, nitrides and sulfides, and to the evaporation of volatile impurities. Better control of composition is attained by eliminating losses of critical elements that would otherwise occur by reaction with gases.

Such control over impurities and alloy content is pointless in alloys having wide composition limits or in which susceptibility to impurities is not a factor. There are, however, numerous applications where composition and cleanliness are extremely important and air melting does not give the consistent results required. This is the field where vacuum melting can be most useful.

As an example of the improvement that can be obtained by vacuum melting, the authors pointed to what had been achieved with Waspaloy, a nickel base alloy containing 18 to 21 chromium, 12 to 15 cobalt, 3.5 to 5 molybdenum, 2.75 to 3.25 titanium and 1 to 1.5% aluminum. This alloy was

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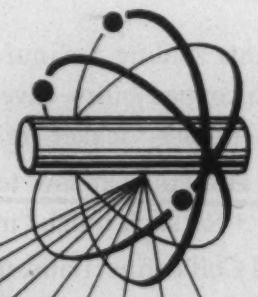

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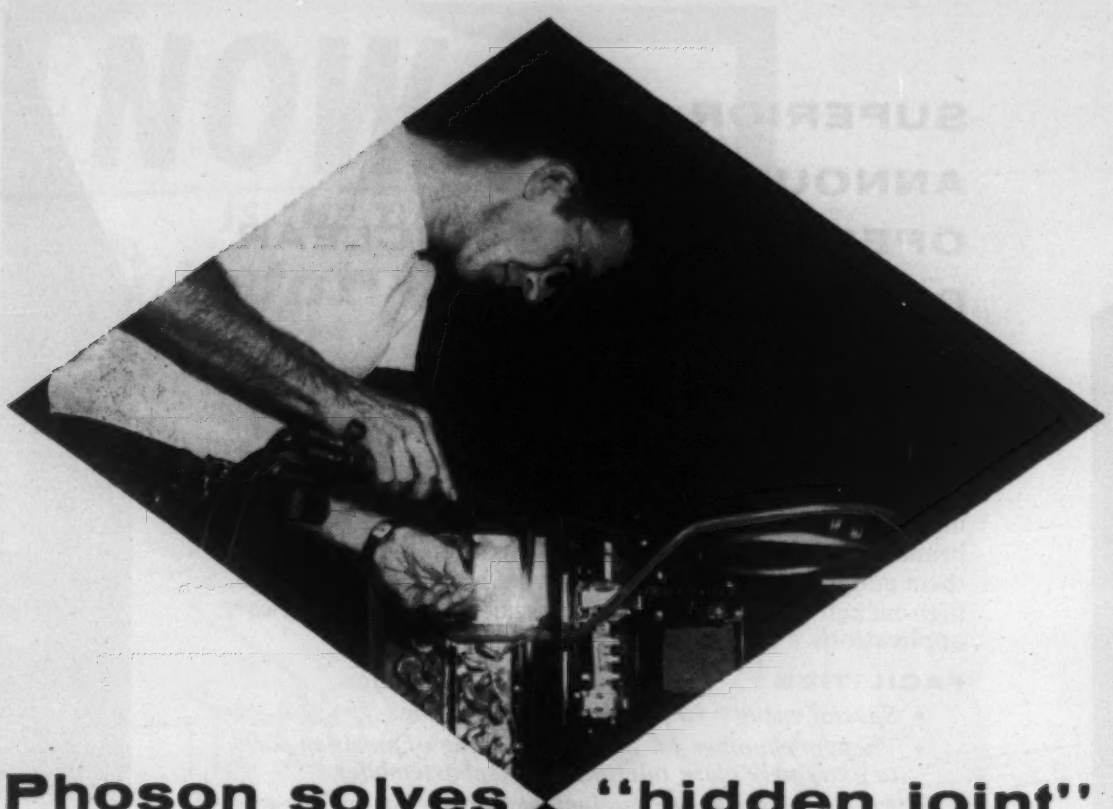

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forged into turbine blades that had to meet a stress-rupture specification of greater than 40 hr life at 1500 F under a stress of 32,500 psi. It is difficult to meet this requirement consistently by air melting. Some heats had 100 hr life under these conditions, but others failed in as little as 20 hr. Production melting of Waspaloy in a vacuum furnace increased the average life to 250 hr, with a minimum of 210 hr and a maximum of 290 hr. Data on a number of production heats show that there was a threefold improvement in stress-rupture life.

Similar results were obtained by melting other nickel base alloys. In every case a decided improvement in stress-rupture life and ductility was noted when vacuum melted and air melted heats were compared.

Impact Properties of Boron-Treated Steel

Boron treated steels have been in use for more than a decade but their properties are still being established. Recently S. J. Rosenberg and J. D. Grimsley of the National Bureau of Standards, completed a comprehensive investigation of the effect of boron on impact properties. Their results were reported in the March issue of *The Journal of the Iron and Steel Institute* (British).

Twenty-one steels from the same open hearth heat with a base composition of 0.43 carbon, 1.60% manganese were treated with boron, added by means of seven different intensifiers. Impact properties were determined over the range –140 to 140 F after tempering at various temperatures.

Boron improved the impact properties of steels tempered at 400 F but appeared to be detrimental to the impact properties of steels tempered in the range 800 to 1200 F and air cooled. Ex-

For more information, Circle No. 545 ›

tent of this detrimental effect depended on type of addition agent, amount of boron and tempering temperature. Considering its overall effect, it appears that boron can be added in amounts up to 0.0025% without significantly affecting impact properties.

Galvanic Corrosion of Titanium, Zirconium

Knowledge of the galvanic corrosion properties of titanium and zirconium is essential because of the growing industrial importance of these metals and the probability that they will be used in structural contact with other metals in corrosive environments.

In Bureau of Mines report RI 5201, David Schlain, C. B. Kenahan and Doris V. Steel discuss the galvanic corrosion effects resulting from coupling titanium and zirconium with a series of dissimilar metals. Couples were immersed in synthetic sea water, tap water and a number of chemical reagents.

Titanium and zirconium resist galvanic attack when in contact with certain structural metals in synthetic sea water, tap water, 5% ammonium sulfate solution, 5½% sodium chloride solution, sodium hydroxide solutions and 0.1 N hydrochloric acid. The dissimilar metals involved include magnesium, magnesium alloy FS1, several aluminum alloys, zinc, lead, tin, copper, Monel, nickel, low alloy steel and stainless steel.

In contact with an aluminum alloy in 1-N sulfuric acid with a limited supply of air, titanium is subject to galvanic attack at a moderate rate. No attack occurs in this solution if a flow of air is maintained. Aluminum alloys are always anodic to zirconium in sulfuric acid solutions. Neither titanium nor zirconium is subject to galvanic attack in sulfuric acid concentrations up to 2-N when coupled with stainless steels.

(Books on next page)

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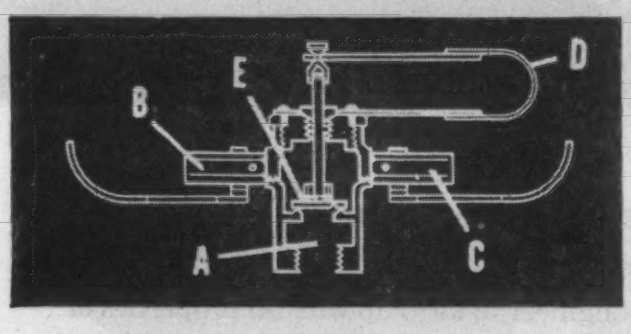

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BOOKS

Colloquium on Fatigue. Proceedings of International Union of Theoretical and Applied Mechanics, Stockholm, May 25-27, 1955. *Springer-Verlag, Berlin, Germany. 1956. Cloth, 6½ by 9 in. 339 pp. Price about $11.25.*

Of the 35 lectures included in the book, 18 are in English, the rest in French or German. The topics include statistical theory of fatigue, cumulative damage, mechanism of fatigue, metallurigal aspects of fatigue, velocity of formation of fatigue cracks, fatigue at elevated temperatures and fatigue under combined stress. The book is illustrated with photographs, graphs and drawings.

Transactions of the American Society for Metals. Vol. 48, 1956. *American Society for Metals, Cleveland 3, Ohio. 1956. Paper, 6 by 9 in. 1061 pp. Price $10.*

This volume contains the technical papers and educational lectures presented at the 37th annual convention of the ASM, held in Philadelphia, Oct '55. One of the most timely of these papers is "High Nitrogen Austenitic Chromium-Manganese Steels," by V. F. Zackay, J. F. Carlson and P. L. Jackson.

1956 SAE Handbook. *Society of Automotive Engineers, Inc., New York 18. 1956. Cloth, 8¾ by 11¼ in. 1172 pp. Price $20.*

The latest edition of this well known handbook contains 18 new reports and 69 revised reports. Among the new reports are "Prevention of Corrosion of Metals" and "Special-Purpose Alloys (Superalloys)."

The Mechanical Properties of Wrought Phosphor Bronze Alloys. *G. R. Gohn, Jr., P. Guerard and H. S. Freynik. American Society for Testing Materials, Philadelphia 3. 1956. Paper, 6 by 9 in. 120 pp. Price $3.*

This paper shows the effect of cold working on the mechanical properties of a series of eight phosphor bronze alloys in the form of cold rolled strip. Tin content of these alloys varied from 0.5 to 10%. Tensile strength, proportional limit, yield strength at both 0.01 and 0.2% offset, modulus of elasticity, elongation, bending fatigue characteristics and Rockwell Hardness (B and 30 T values) are reported for six different tempers of each material.

(Reports on p 218)

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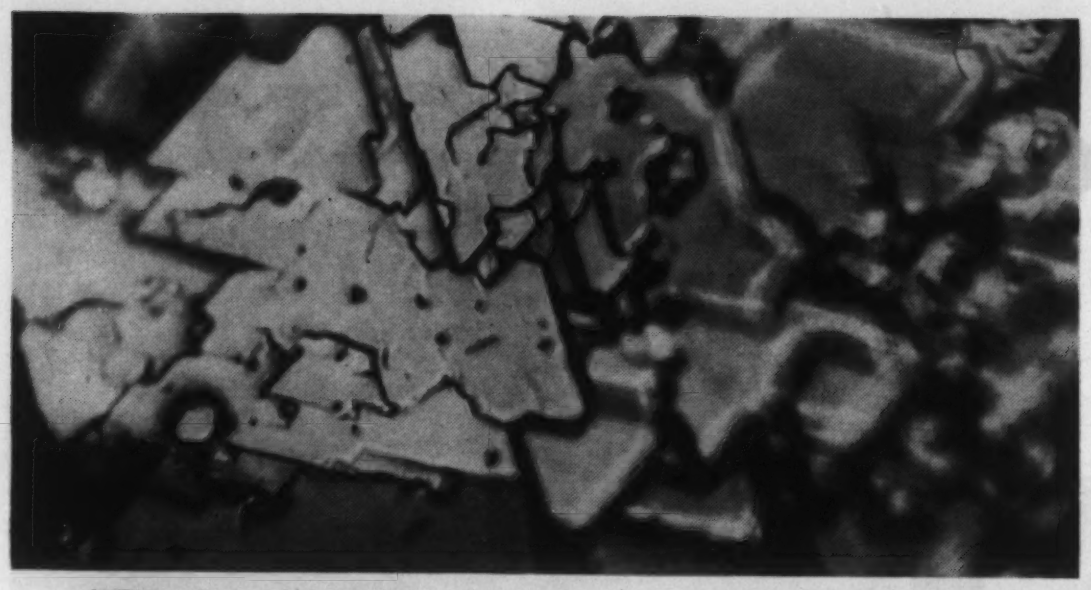

$WTiC_2$ Crystal (4000X). Photomicrograph of Kennametal tungsten-titanium crystal (4000X). This unique material is an important ingredient of Kennametal, and provides a combination of desirable characteristics in the steel-cutting and gall-resistant grades of Kennametal.

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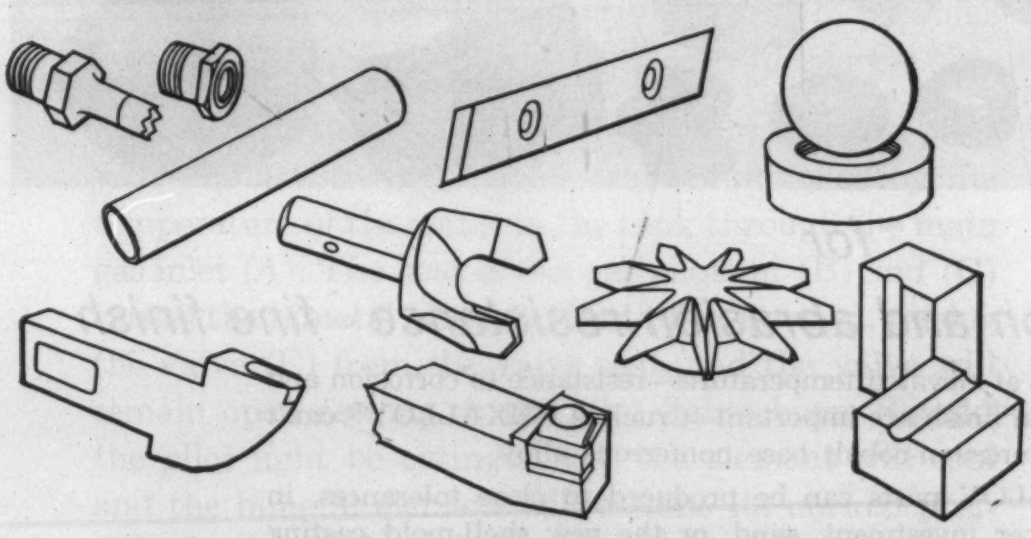

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CONTENTS NOTED

REPORTS

Gases in steel EFFECT OF GASES IN STEEL. *J. A. Rinebolt and R. H. Raring, Naval Research Laboratory. Jan 1956. 23 pp, photo, graphs, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. 75¢. (PB 111899)*

AISI 4340 steels melted in air, in vacuum and in an argon atmosphere were heat treated to strength levels ranging from 150,000 to 290,000 psi and compared with respect to tensile properties, Charpy V-notch properties, susceptibility to static fatigue failure in notch tensile test, and susceptibility to embrittlement from cathodic charging and cadmium plating. No significant benefits were conferred by vacuum melting or by melting in argon.

Electroforming copper ELECTROFORMING OF COPPER FOR HIGH-VACUUM APPLICATIONS. *L. H. La Forge, Jr., Stanford Univ. 23 pp, photos, diags. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. 75¢. (PB 111960)*

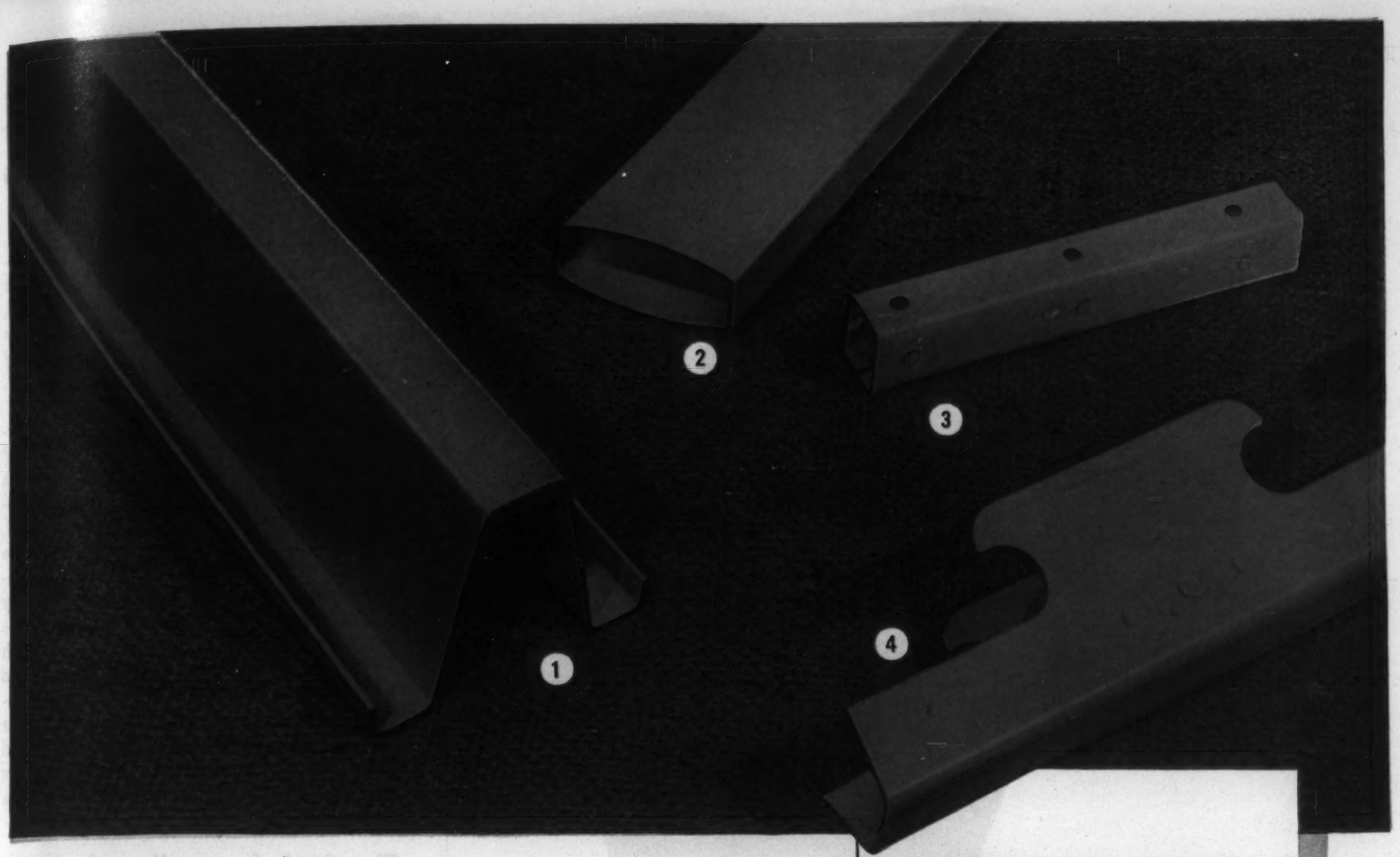
Waveguides and similiar microwave components were formed 0.150 in. thick on stainless steel mandrels in an acid copper bath at room temperature with current density of 10 amp per sq ft. Linear-accelerator sections were also formed. Both compositions and operating variables given.

Carbides, nitrides, borides INVESTIGATION OF THE EFFECT OF RAW MATERIAL PRODUCTION VARIABLES ON THE PHYSICAL AND CHEMICAL PROPERTIES OF CARBIDES, NITRIDES AND BORIDES. *H. Blumenthal, American Electro Metal Corp. June 1955. 105 pp, photos, diags, graphs, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. $2.75. (PB 111989)*

Cathodic protection MAJOR FACTORS IN THE CATHODIC PROTECTION OF STEEL IN SEA WATER. *L. J. Waldron, E. E. Nelson and M. H. Peterson. Naval Research Laboratory. Aug 1955. 21 pp, graphs, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. 75¢. (PB 111807)*

Water resistivity and polarization are major factors influencing current distribution in cathodic protection. Relatively high water resistivity tends to give nonuniform distribution of current whereas high polarization produces uniform distribution.

(more Reports on p 220)



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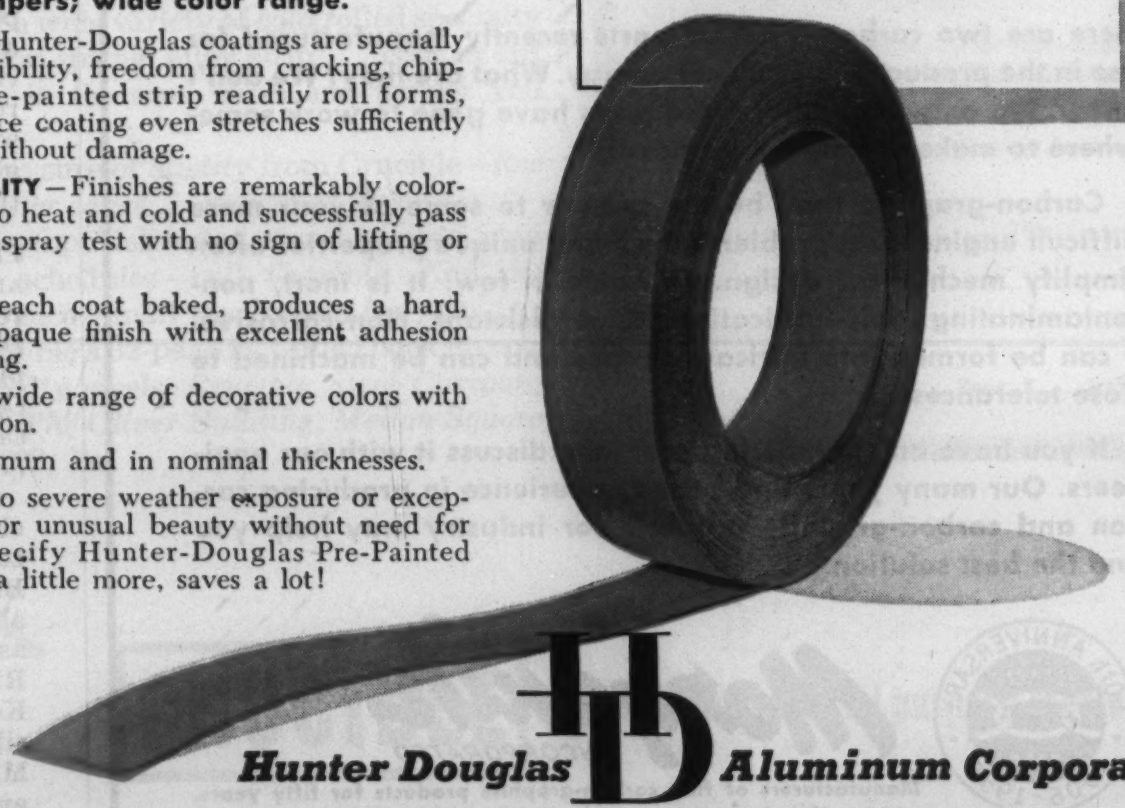

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CONTENTS NOTED

REPORTS

Elastomers ELASTOMERIC DITHIOPOLYESTERS. *F. W. Knobloch, Wright Air Development Center. June 1955. 25 pp, graph, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. 75¢. (PB 111949)*

Two types of elastomers were prepared from an experimental liquid polymer formulation derived from a condensation product of mercaptoacetic acid and triethylene glycol. One was obtained by reaction of the liquid polymer with organic and inorganic peroxides, and the other by reaction of terminal mercapto groups with unsaturated aldehydes. Each type was successfully compounded and vulcanized on conventional rubber processing equipment. Behavior of these vulcanizates in fuels and synthetic ester base oils, and effects of aging at elevated temperatures were studied.

Fluorinated acrylic elastomer POLY FBA, A FLUORINATED ACRYLIC ELASTOMER FOR HIGH TEMPERATURE SERVICE IN THE PRESENCE OF AIRCRAFT FUELS AND LUBRICANTS. *Horace C. Hamlin, Wright Air Development Center. Nov 1955. 60 pp, photos, graphs, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. $1.50. (PB 111946)*

One of the most successful of a large number of fluorine-containing polymeric systems developed by Minnesota Mining & Mfg. Co. under an Air Force contract, developments, is poly 1, 1-dihydroperfluorobutyl acrylate (poly FBA). It exhibits good rubbery characteristics and excellent resistance to many fuels, lubricants, solvents, chemicals and ozone, plus good stability at elevated temperatures.

Fluorocarbon elastomer STUDY AND EVALUATION OF KEL-F ELASTOMER. *R. E. Headrick, Wright Air Development Center. Oct 1955. 41 pp, graphs, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. $1.25. (PB 111984)*

Optimum properties of Kel-F elastomer are obtained by using benzoyl peroxide as the curing agent. Brittle point of Kel-F elastomer is about —50 F. Compounded Kel-F elastomer has excellent resistance to RFNA. Immersion tests indicate Kel-F elastomer should be useful in silicate ester type fluids up to 400 F. Material showed satisfactory resistance to 70-30 type fuel at room temperature. Use of Kel-F elastomer in contact with fuels at higher temperatures may be possible.

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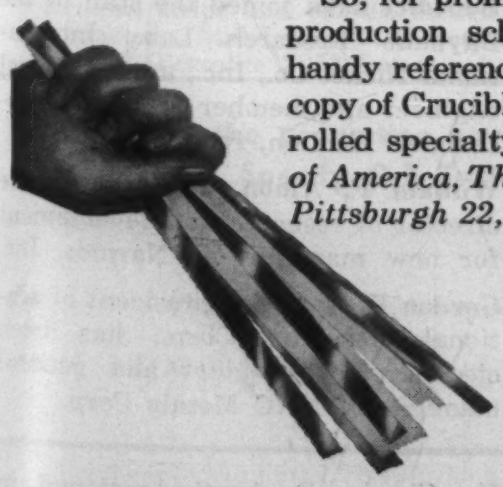

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NEWS OF ENGINEERS COMPANIES SOCIETIES

Herbert C. Vacher, head of the metallographic and X-ray diffraction laboratory, National Bureau of Standards, has been awarded the Dept. of Commerce Silver Medal for Meritorious Service for his contributions to the field of metallurgy.

Charles R. Funk has been promoted to manager of metallurgy and engineering, ALCO Products, Inc.

Remus A. Lula, formerly research supervisor for Allegheny Ludlum Steel Corp., is now associate director of research—stainless steel.

Dr. Eraldus P. Scala has been named chief of the materials section of Research and Advanced Development Div., Avco Mfg. Corp.

Charles S. Anderson, president, Belle City Malleable Iron Co., was presented the Charles H. McCrea Award by Malleable Founders' Society at its recent annual meeting.

Edward W. Hackney has joined Herbrand Div. of Bingham-Herbrand Corp. as manager of research and development.

Arnold S. Grot is chief metallurgist at Edward Valves, Inc.

A. E. Smith has been appointed chief project engineer in the General Engineering Dept. of Electro Metallurgical Co. Promotions in the company's Product and Process Development Dept. are: **W. O. Binder,** assistant manager, and **E. R. Saunders,** assistant to manager.

Frank A. Votta, Jr., has rejoined Hunter Spring Co. as chief engineer.

John E. Chard and **Dr. Joseph T. Benedict** have joined the staff of the Bayonne Research Lab., International Nickel Co., Inc., as mechanical engineer and member of the Electrochemical Section, respectively.

William F. Amon, Jr., is associate director of research and development for new materials at Narmco, Inc.

Gordon Kiddoo, vice president of National Research Corp., has been elected vice president and general manager of NRC Metals Corp.

Dr. Charles R. Austin, assistant to the president of Meehanite Metal Corp., died recently after a brief illness.

(News of Companies on p 224)

For more information, turn to Reader Service Card, Circle No. 519

Laminate is shown in actual size.

Textolite®

2053 HOT PUNCH LAMINATE

G-E Textolite 2053, a phenolic paper base laminate, serves three important terminal board functions in the advanced G-E general purpose fractional horsepower motors. As the motor nerve center it supports: (a) the internal and external connections; (b) the switch that starts and runs the motor; and (c) the overload.

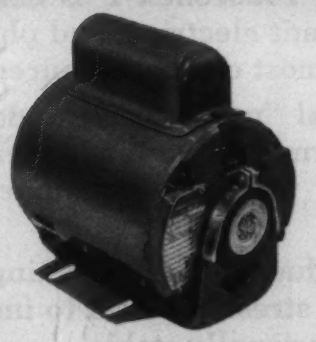
Hot punched in a thickness of 1/64", Textolite 2053 has excellent strength to support these components under external vibrations without cracking, and necessary stability to maintain the switching operations over long periods of time, under all operating conditions. (Life test runs up to 3½ million switching operations without failure.)

The superior punching properties of G-E Textolite 2053 permits close tolerance punching. Accurate hole sizes are maintained at minimum distances without fracturing the laminate. The arc resistance of the material allows close arrangement of the electrical components, minimizing the possibility of carbon tracks causing motor failure.

G-E Textolite 2053 offers many opportunities for use in terminal strips and boards, sockets, spacers, panels and contactors. Make sure YOU get all the important facts on G-E Textolite 2053 hot punch laminate.

When the properties have to be right . . .
Specify G-E Textolite®

The Nerve Center of the G-E "Years Ahead" FHP Motors



Advanced design General Electric general purpose capacitor start fractional horsepower motor.

Terminal board of G-E Textolite 2053 hot punch laminate forms the nerve center of the motor.

Progress Is Our Most Important Product

GENERAL ELECTRIC

G-E Textolite® Laminated Sheets, Rods & Tubes
Irrathene® Irradiated Polyethylene • Silicone Insulation
Mica & Mica Mat Insulation • Insulating Varnishes
Varnished Cloth & Tapes • Sealing & Filling Compounds

General Electric Company
Laminated and Insulating Products Department
Section MML-86, Coshocton, Ohio

☐ *Please send me technical data on G-E Textolite® 2053 hot punch laminate.*
☐ *Please have your representative call.*

Name _____

Title _____

Firm _____

Street _____

City _____ Zone _____ State _____

For more information, turn to Reader Service Card, Circle No. 529

Important! Specify TEFLON® by its properties!

TEFLON *can* provide extraordinary physical, electrical, and chemical properties, but these properties *cannot* be taken for granted.

The method used to convert Teflon powder into finished rods, sheets, and tubes greatly affects the quality obtained. This quality, in turn, governs the properties of the end product.

So to *assure* performance, actually specify not only Teflon but also the important *properties* required.

Two grades of Fluoroflex®-T deliver the *optimum* properties you specify for Teflon.

(1) "Electrical grade" Fluoroflex-T is certified to conform to all important electrical and physical properties. It meets the most critical requirements.

(2) A more economical "mechanical grade" satisfies all chemical and thermal needs and offers up to 50% greater resistance to elongation under mechanical loads.

Both grades are produced under exacting quality control standards and are stress relieved to insure that machined parts are dimensionally stable.

Send for data or better still tell us what specific properties are important for your application.

® *Teflon is a DuPont trademark. Fluoroflex is a Resistoflex trademark.*

RESISTOFLEX

CORPORATION • **Roseland, N.J. Western Plant: Burbank, Calif.**

Warehousing Distributors: Western Fibrous Glass Products, Los Angeles, Calif.; F. B. Wright Co., Detroit, Mich.; Colonial Kolonite Co., Chicago, Ill.; Industrial Safety Supply Co., Hartford, Conn.; Lone Star Rubber Co., Houston, Tex.; Flow Products, Inc., Chicago, Ill.

For more information, turn to Reader Service Card, Circle No. 508

news of | COMPANIES

Metal & Thermit Corp. has acquired **Glenn Co.** The business is being moved to new quarters at 703 87th Ave., Oakland, Calif., where it will be operated as a manufacturing subsidiary under the name, **M & T Welding Products Corp.**

Radio Corp. of America has made plans to establish an Advanced Development Lab. in the New England Industrial Center at Needham, Mass. The plant will be utilized for advanced developmental work on ferrites.

Sylvania Electric Products, Inc.'s Parts Div. has revealed plans for a new plastics plant to be erected in Warren, Pa.

Firestone Tire & Rubber Co. has disclosed an investment of approximately $50,000,000 in synthetic rubber and petrochemical manufacturing plants in Ohio, Louisiana and Texas. The investment will cover present and projected construction to provide, in addition to basic chemicals, more than 200,000 tons of synthetic rubber a year.

W. R. Grace & Co. has announced that the headquarters and applications laboratories of the newly formed Polymer Chemicals Div. will be located in Clifton, N. J.

Hewitt-Robins, Inc., will establish a new 100,000-sq-ft plant on ten acres of land in Franklin, N. J., to manufacture polyurethane foam. The plant, scheduled to be completed Sep 1, will have an annual production capacity of 2,000,000 lb.

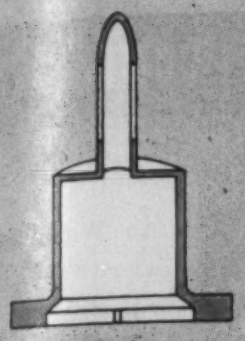
Misco Fabricators, Inc., now occupies larger and more modern quarters at 3564 Toledo Ave., Detroit 16, Mich.

American Steel & Wire Div. of U.S. Steel Corp. has erected a new rod mill which is expected to reach its annual capacity rate of production of 450,000 tons before the end of the year. Known as No. 1 Rod Mill, it will eventually replace the yearly 360,000-ton output of No. 2 and 4 Rod Mills placed in operation in 1916.

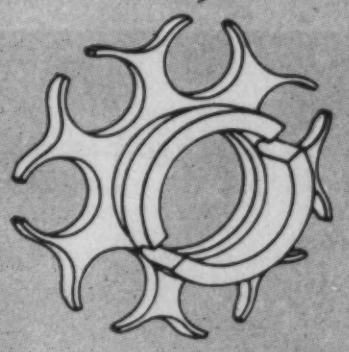
Vanadium Corp. of America will build a new plant for the production of ferroalloys near New Alexandria, Ohio.

C. H. Wheeler Mfg. Co. has announced that the name of its weldment division has been changed from

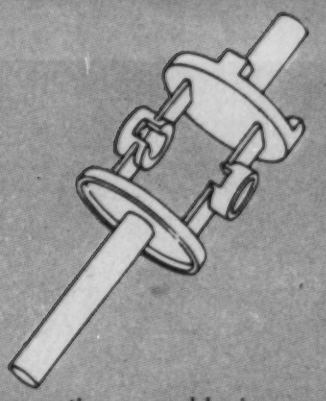
For more information, Circle No. 520 ➤



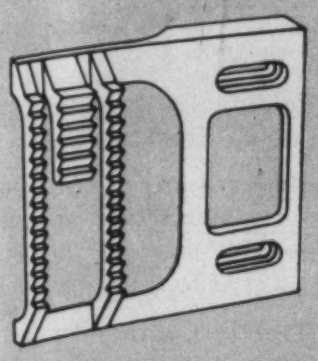
...re is an example of the complex in-...rnal coring possible with investment ...sting. Square, round, elliptical or ir-...gular interiors can be cast.



The complexity of this part makes investment casting the only feasible method of manufacture. Prongs have perfect dimensional accuracy.



Here an entire assembly incorporating multiple functions is cast in one unit. "Keyhole" coring and a number of distinct surface details are required.



The sharp teeth of this sewing machine ...eed dog were cast in wear-resistant al-...oy to give longer wear than could be ...btained from machinable material.

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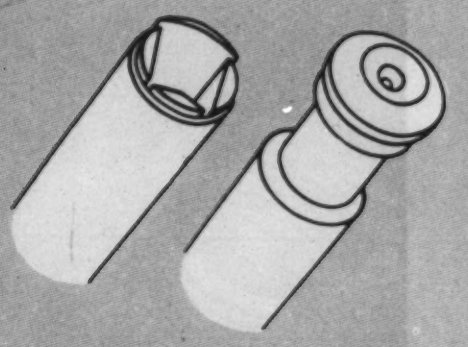
austenal

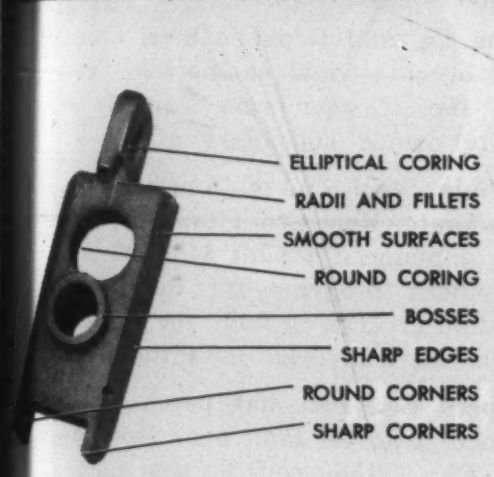
in mind

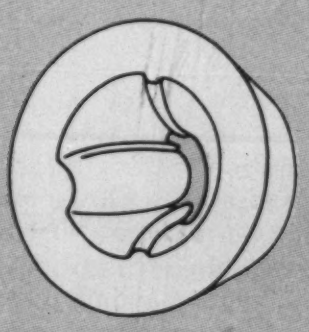
In planning parts, design directly for Microcast and take advantage of its wide range of design possibilities.

See not only what you can do, but what costly, time-consuming operations Austenal investment casting eliminates.

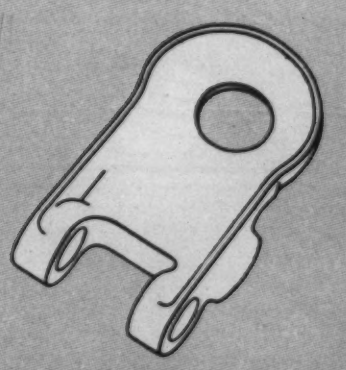


Cross-sections of irregular and varying thickness can be utilized. In this part the internal core diminishes from an irregular square to a small round hole.

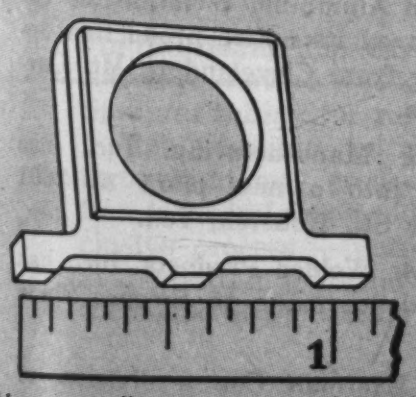




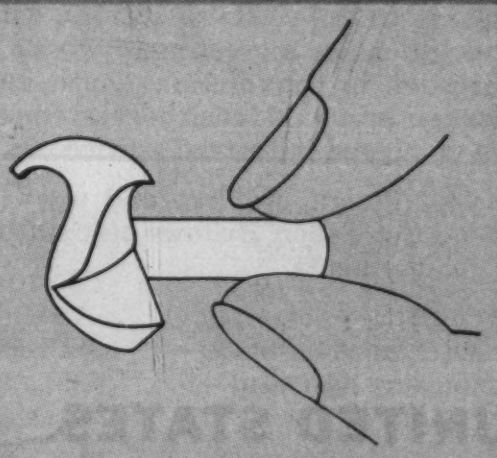
These extrusion dies of wear-resistant alloy are readily mass-produced with highly complex and irregular internal contouring.



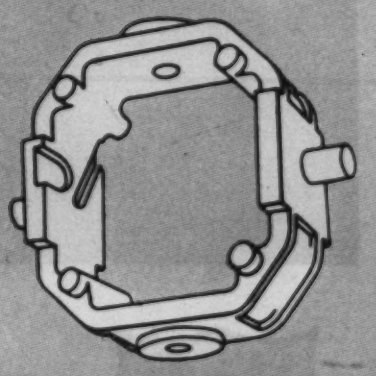
Walls of varying cross-sections are possible. Here wall thicknesses change from thin to very heavy, allowing strength without bulk.



This very small part measures 1⅛" wide and less than ⅛" thick. Its thinness, rigidity and detail were possible only by investment casting.



Shown here is an example of how investment casting can virtually eliminate hand-filing and machining by keeping uniform, intricate detail.



This large complex gimbal was cast to include many details on the internal and external surfaces.

Design problem?

Call your Austenal representative and ask him to show you how Microcast can help you.

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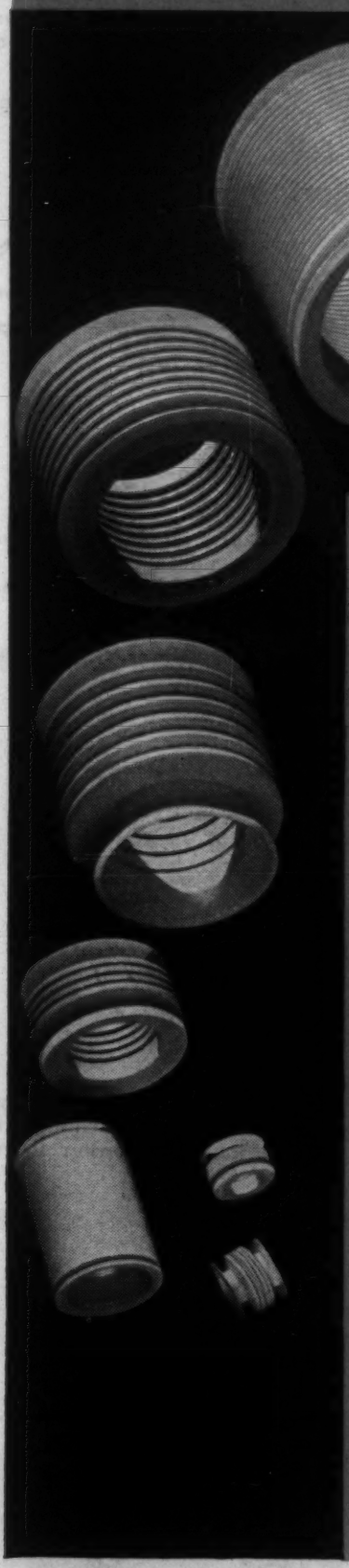

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The Teflon Bellows, originated and developed to its present widespread application by the United States Gasket Company, is one of the most versatile mechanical elements that laughs at corrosion and contamination.

It is adapted to use as expansion chambers, seals for packless valves, rotating shaft seals, pumping elements, pressure measuring elements, flexible piping sections, pulsing elements, mechanism shields, thermal expansion elements, flexible hermetic seals, vibration dampeners, piping swing joints, flexible couplings and many other equipment and instrument applications in the chemical, atomic energy, food, pharmaceutical and biological fields.

U. S. G. Teflon Bellows have been custom made in sizes from ½" ID to 18" ID, with few convolutions or a great many, with a wide variation in convolution depth and wall thickness provided for either extremely sensitive or rugged industrial service.

Tell us your design problem and we will recommend the Teflon Bellows best suited to your requirements.

U S G BELMONT

UNITED STATES GASKET COMPANY

CAMDEN 1, NEW JERSEY

*du Pont's trademark for its tetrafluoroethylene resin.

For more information, turn to Reader Service Card, Circle No. 395

news of | COMPANIES

Cruse-Kemper Div. to Wheelerweld Div.

Aluminum Co. of America has announced plans to install a second 14,000-ton extrusion press at its Lafayette, Ind., works.

American Can Co. has appropriated $27 million for installation of new manufacturing facilities at various points in the country to process tin and steel plate from continuous strips.

American Molding Co. is building a new plant in San Leandro, Calif.

Auto-Air Industries has been formed to design and manufacture automotive and aircraft tooling. The new company is located in Lansing, Mich.

Caterpillar Tractor Co. recently dedicated a new motor grader and wheel-type tractor plant in Decatur, Ill.

Continental Can Co. and **Hazel-Atlas Glass Co.** have announced plans for merger of the two businesses.

Crane Co. and **Republic Steel Corp.** have become equal partners in **Cramet, Inc.** Cramet was formerly a wholly owned subsidiary of Crane.

Crucible Steel Co. of America and its affiliate, **Rem-Cru Titanium, Inc.**, have announced a joint $400.000 improvement program for increasing titanium processing facilities at Crucible's Park Works in Pittsburgh.

Koppers Co., Inc., has purchased a 176-acre tract of land near Monroeville, Pa., as the site for a new multimillion dollar research center.

Molded Latex Products, Inc., has changed its name to Kaysam Corp. of America.

Morgan Aluminum Welding Rod Co. has moved its entire production operation from Cleveland to Mt. Carmel, Pa.

Snelling Manufacturing, Inc., has moved into a new plant at 2601 Magnet St., Houston, Tex.

Stainless Welded Products, Inc., has changed its name to **Swepco Tube Corp.**

Texas Eastman Co., a division of Eastman Kodak Co., will broaden its work in the field of high density, low pressure polyethylene plastics by construction of a semicommercial manufacturing unit at its plant in Longview, Tex.

(News of Societies on p 228)

now available from Trent–

Titanium Tubing

For processing lines carrying fluids of an extremely corrosive nature — look to *Contour Trentweld* titanium tubing for reliable service.

This titanium tubing is completely uniform throughout any cross-section. The weld zone is free from bulging weld bead because Trent's exclusive process — performed with the weld area at the bottom — forms the molten weld metal into the shape of the tubing.

And, with titanium, you get the unique advantages of a tubing that's strong as steel but 44% lighter . . . virtually immune to a broad spectrum of corrosive materials . . . entirely free from stress-corrosion cracking.

So, next time you need a strong, light, extremely corrosion-resisting tubing—try *Contour Trentweld* titanium tubing. And remember, it's made by Trent — tube mill specialists.

CONTOUR TRENTWELD

Stainless and High Alloy Welded Tubing

TRENT TUBE COMPANY, GENERAL SALES OFFICES, EAST TROY, WISCONSIN (Subsidiary of Crucible Steel Company of America)

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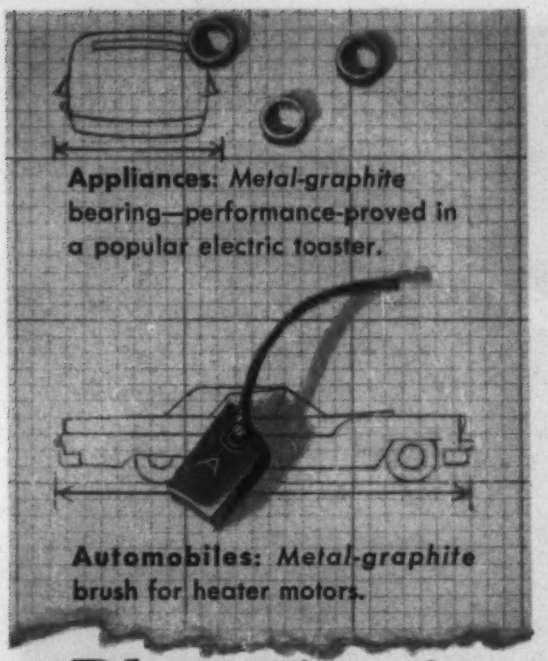

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Carbon – one of industry's most versatile materials—constantly finds new applications in the latest product designs.

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Carbon Is Really Versatile!

Carbon can be:	Carbon has:
Sawed	High corrosion resistance
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Planed	**Carbon is:**
Hobbed	Not wetted by molten metals
Ground	Non-warping
Molded	Chemically inert
Extruded	Self-lubricating

Let Speer engineers and designers help you discover the many advantages – and economies – that carbon can bring to your product!

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St. Marys, Pennsylvania

Please send me information on:
— Molded carbon parts
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For more information, Circle No. 537

news of | SOCIETIES

Metal Powder Assn. has announced the appointment of Kempton H. Roll as the association's first full-time executive secretary and treasurer. At the time of his appointment, he was technical director of both the Metal Powder Assn. and the Lead Industries Assn.

The association has occupied new offices located at 130 W. 42 St., New York City.

American Iron and Steel Institute, at its recent general meeting, accepted the resignation of H. G. Batcheller, chairman, Allegheny Ludlum Steel Corp., as director, and elected the following new directors: E. J. Hanley, president, Allegheny Ludlum Steel Corp., and Max D. Howell, executive vice president.

American Society for Testing Materials has elected the following new officers: president — Rudolph A. Schatzel, vice president and director of engineering, Rome Cable Corp.; vice president—Kenneth B. Woods, head, School of Engineering, and director, Joint Highway Research Project, Purdue University; directors —Miles N. Clair, president, Thompson & Lichtner Co., Inc.; Howard C. Cross, assistant technical coordination director, Battelle Memorial Institute; George H. Harnden, consultant, materials and processes, Engineering Standards Service, General Electric Co.; R. R. Litehiser, engineer of tests, Ohio State Highway Testing Lab.; and Charles R. Stock, senior group leader, Physical Measurements Labs., American Cyanamid Co.

The society honored eleven technical leaders in the field of engineering materials with Awards of Merit during its recent annual meeting. Among them were Harry A. Bright, chief, Analytical Chemistry Section, Div. of Chemistry, National Bureau of Standards; Simon Collier, director of quality control, Johns-Manville Corp.; William LaVilla Fink, chief, Physical Metallurgy Div., Aluminum Co. of America; Bruce W. Gonser, assistant director, Battelle Memorial Institute; Roland P. Koehring, section engineer for research and development, Moraine Products Div., General Motors Corp.; and Vincent T. Malcolm, consultant and advisory engineer, Chapman Valve Mfg. Co.

Those elected to Honorary Membership in ASTM include: Albert E. White, consulting metallurgical engi-

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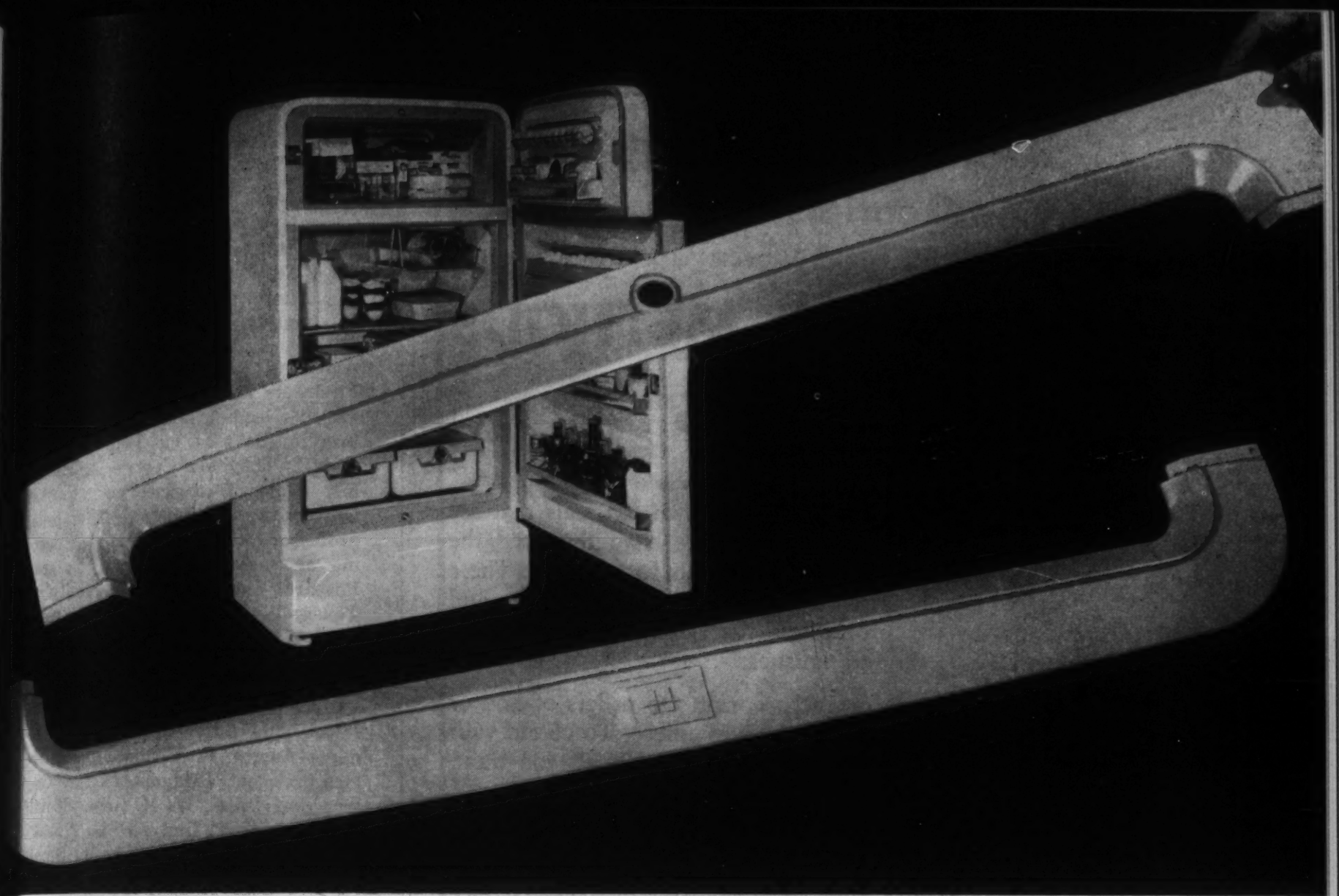
Kawneer General Offices NILES MICHIGAN
MILL PRODUCTS DIVISION
1906–1956

For more information, Circle No. 405



Breaker strips molded of impact styrene are used on door and door frame of refrigerator made by **Hotpoint Co.**, Chicago 44, Ill.

Why breaker strips for Hotpoint are made from BAKELITE impact styrene

Here are the average properties of BAKELITE Brand Impact Styrene TMD-5151 based on laboratory tests:

Specific gravity* (ASTM D-792-50)	1.04-1.09
Izod Impact, ft/lb/in. of notch ⅛ in. bar (ASTM D-256-47T)	
74 deg. F.	3.5
32 deg. F.	2.0
−13 deg. F.	0.7
Tensile Strength, psi (ASTM D-638-49T)	4,300
Elongation in Tension, %	30
Flexural Strength (ASTM D-790-49T)	no failure
Modulus of Elasticity, psi	375,000
ASTM Heat Distortion (¼ in. thick, 264 psi) Deg. F.	176

*value will vary with color

These breaker strips for the Hotpoint refrigerator withstand day-in, day-out service in hundreds of thousands of homes. They demonstrate the toughness of TMD-5151, the BAKELITE Brand Impact Styrene from which they're molded.

They stand up under the impact of continual slamming at refrigerator temperatures. Their dimensional stability assures a snug fit. Accurately molded details and uniformity of color result in closely-matched sections. The high surface gloss withstands household cleaning solutions.

Learn how to apply the advantages of TMD-5151 to your product designs. Qualified technical assistance is available from Bakelite Company to fit this material to your needs. Consult your plastics molder or write Dept. SE-108.

BAKELITE BRAND PLASTICS

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N.Y.

In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario

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news of | SOCIETIES

neer; H. J. Gilkey, head of Dept. of Theoretical and Applied Mechanics, Iowa State College; H. B. Oatley, consultant; and James T. MacKenzie, Southern Research Institute.

American Society of Mechanical Engineers has elevated three of the nation's leading engineering educators to the rank of Fellow of the ASME. They are George A. Hawkins, dean of engineering, Purdue University; Milton J. Thompson, professor of aeronautical engineering and associate director, Defense Research Laboratory, University of Texas; and Ford Lee Wilkinson, Jr., president of Rose Polytechnic Institute.

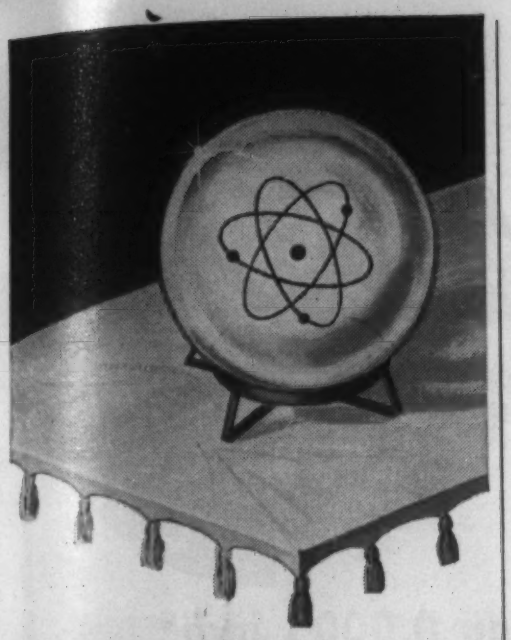
Copper & Brass Research Assn. has relected the following officers: president—Austin R. Zender, executive vice president, Bridgeport Brass Co.; vice presidents—W. M. Goss, Scovill Mfg. Co.; J. P. Lally, C. G. Hussey & Co.; and E. A. Oliphant, Small Tube Products, Inc. Newly elected vice presidents are J. M. Kennedy, Revere Copper and Brass, Inc.; Terry W. Kuhn, Bohn Aluminum & Brass Corp.; W. W. Sieg, Titan Metal Mfg. Co.; and D. W. Blend, Wolverine Tube Div., Calumet & Hecla, Inc.

National Assn. of Corrosion Engineers has formed a new technical unit committee to concentrate on industrial maintenance painting problems. The unit is called T-6D on Industrial Maintenance Painting in the Process Industries.

The 51st local section of the NACE received its charter Apr 17 at Great Bend, Kan. It will be known as the West Kansas Section.

National Electrical Manufacturers Assn. has announced the election to membership of six more electrical manufacturers. They are Dixie Raydiant Electric Heat Corp.; Rentip, Inc.; Sundial Electric Co., Div. of Slant-Fin Radiator Corp.; Great Northern Mfg. Corp.; Ralph Wilson Plastics, Inc.; and A. O. Smith Corp., Electric Motor Div.

National Screw Machine Products Assn. has announced that the following companies have recently joined the association: Arrow Machine Products Co., Howell Automatic Machine Co., Wood-Sebring Corp., Sherman Screw Products Co., Duffin Mfg. Co., and Y. W. Small Parts, Ltd.



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Atomic power, we feel, offers outstanding opportunity for an engineer or scientist to grow professionally. It's new enough so that the work is challenging; still it's well enough established so that a capable man can make real progress.

If you are interested in a non-routine position that will use all of your education and experience, we suggest you investigate the future with the leader in Atomic Power. At Bettis Plant, there are select positions open for specially qualified:

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Write for the booklet "Tomorrow's Opportunity TODAY" that describes opportunities in your field. Be sure to indicate your specific interests.

Write: Mr. A. M. Johnston
Dept. A-55
Westinghouse Bettis Plant
P. O. Box 1468
Pittsburgh 30, Penna.

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For more information, Circle No. 403

Meetings and Expositions

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, fall meeting, Denver. Sep 10-12.

SOCIETY OF AUTOMOTIVE ENGINEERS, tractor meeting and production forum. Milwaukee. Sep 10-13.

AMERICAN DIE CASTING INSTITUTE, annual meeting. Chicago. Sep 11-13.

AMERICAN CHEMICAL SOCIETY, annual meeting. Atlantic City. Sep 16-21.

AMERICAN SOCIETY FOR TESTING MATERIALS, Pacific Coast meeting. Los Angeles. Sep 16-22.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Instruments and Regulators Div., and Instrument Society of America, exhibit and joint conference. New York. Sep 17-21.

PORCELAIN ENAMEL INSTITUTE, annual meeting. Colorado Springs, Colo. Sep 19-21.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, petroleum-mechanical engineering conference. Dallas, Tex. Sep 23-26.

STEEL FOUNDERS' SOCIETY OF AMERICA, fall meeting. White Sulphur Springs, W. Va. Sep 24-25.

ATOMIC INDUSTRIAL FORUM, trade fair. Chicago. Sep 24-28.

ASSN. OF IRON AND STEEL ENGINEERS, iron and steel exposition. Cleveland. Sep 25-28.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, fall general meeting. Chicago. Oct 1-5.

SOCIETY OF AUTOMOTIVE ENGINEERS, aeronautic meeting, aircraft production forum and engineering display. Los Angeles. Oct 2-6.

STANDARDS ENGINEERS SOCIETY, annual meeting. Washington, D. C. Oct 3-5.

MAGNESIUM ASSN., annual meeting. Chicago. Oct 4-5.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS, Institute of Metals Div. Cleveland. Oct 8-10.

SOCIETY FOR NONDESTRUCTIVE TESTING, annual meeting. Cleveland. Oct 8-11.

NATIONAL METALS CONGRESS AND EXPOSITION, American Society for Metals. Cleveland. Oct 8-12.

AMERICAN WELDING SOCIETY, national fall technical meeting. Cleveland. Oct 8-12.

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Write for Bulletin No. 120

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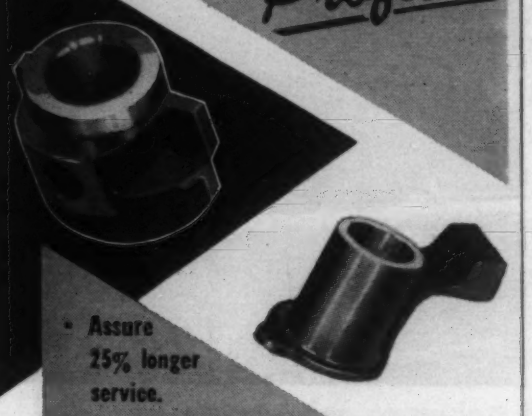

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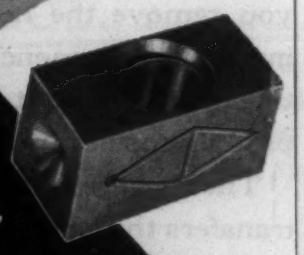
- Will not powder under the most severe service.

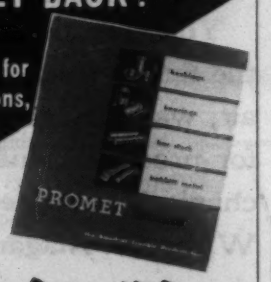


Special formulas, developed for specific or unusual conditions, assure the best combination of physical properties.

Superior Service Guaranteed

OR YOUR MONEY BACK!

SEND PRINTS
and condition of operation for recommendations, quotations, literature and service data sheets.



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For more information, Circle No. 425

MATERIALS ENGINEERING NEWS

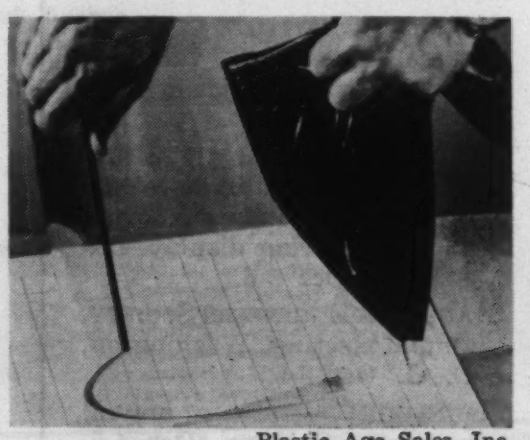
continued from p 13

a 2000-lb production unit. The company is already operating consumable electrode vacuum remelting furnaces on a regular basis.

Extensive research programs are now being conducted on new high temperature wheel and bucket alloys for gas turbines. Also under study are improvements in the production of high temperature bearing steels, tool steels, alloys for magnetic applications and alloys for specialized corrosion service.

Giant Autoclave Built For Adhesive Bonding

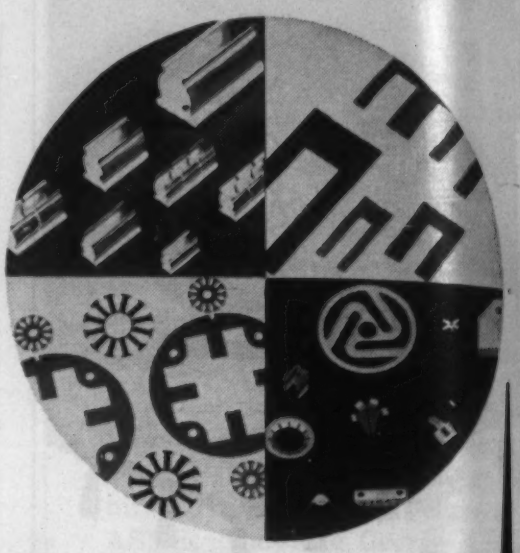
Designing of larger and more complex parts for use on high-speed, high performance aircraft is becoming more dependent upon structural adhesives. However, many of these components have contours that preclude the application of heat and pressure neces-



Plastic Age Sales, Inc.

Forming plastics to any desired shape without distortion and with consistently good optical properties is possible by coating the plastics sheet to be formed with a smooth, pliable plastics material. During the forming process, this coating becomes an integral part of the basic plastics sheet and absorbs all impurities between the die and the sheet that would result in "mark-off." After cooling, the marred coating is peeled off, leaving the surface of the formed article smooth and unblemished.

For more information, Circle No. 396



Can 0.0005 inch precision strip simplify your product design?

From 0.0005 in. to 0.040 in. thick and 0.090 to 6 in. wide, these alloys are available as special-tolerance strip:

Beryllium Copper
Phosphor Bronze
Nickel Silver
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Some immediately available. Others rolled to order in 2 to 21 days. Can be supplied in coils or straight lengths with slit or filed edges—also cadmium plated.

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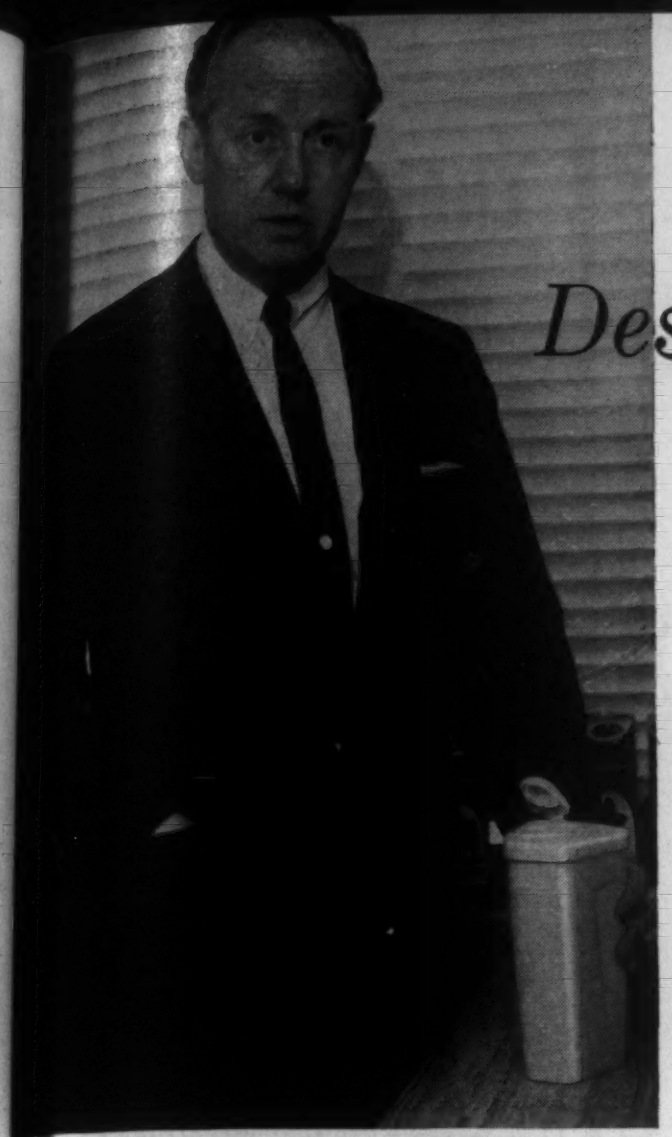

Francis Blod, Design Associates, New York City

Mr. Blod discusses the handsome decanter that won 1st Prize, Class II, in the Koppers 1956 Design Competition with associate George Stehl. The prize-winning decanter is being marketed by Hutzler Mfg. Co., Long Island City, N. Y.

Designer Francis Blod talks plastics:

"This container *had* to be made with polyethylene . . . because it offers so much to the user. It has a soft translucency . . . a graciousness that any housewife will appreciate. It does not rattle and it will be less cold to the touch. This container is safe for children . . . possesses lightness, a cover that won't come off and a non-drip spout. Too much cannot be said for the eye-appeal we get from polyethylene-designed items. We use it whenever possible in designing something that is to appeal to women or children.

"Cost is an element that must be contended with, too. We regard polyethylene as one of the most realistically priced mediums we could work with for the adaptability we require on many projects."

New uses for plastics are being discovered almost weekly. Quite possibly one of *your* products could be made more efficiently with plastics. Koppers manufactures DYLAN* polyethylene, SUPER DYLAN* polyethylene, DYLENE* polystyrene and DYLITE* expandable polystyrene. For more information on any of these products, write to Koppers Company, Inc., Chemical Division, Dept. MM-86, Pittsburgh 19, Pennsylvania, or to any of the sales offices listed below.

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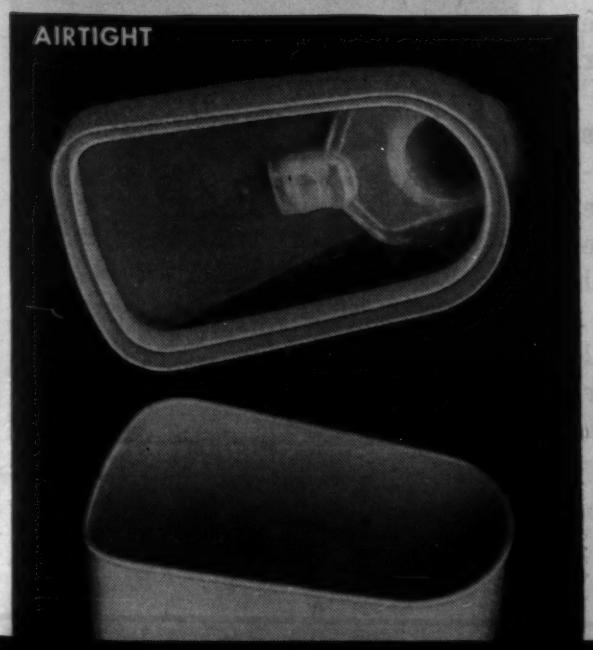

BORAL!

New Lightweight Shield

Boral is the new neutron shielding material made by Alcoa. Boral plate ¼" thick has the shielding power of a concrete slab 100 times thicker!

Boral is a rolled sandwich of boron carbide with aluminum skin. It's available in thicknesses of ⅛" and ¼"; sizes of 48" x 120" and 36" x 96"; annealed or as-fabricated tempers.

For a lightweight, low-cost shielding material, investigate *Boral*. Write, Aluminum Company of America, 2251-H Alcoa Building, Pittsburgh 19, Pennsylvania.

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ALTERNATE SUNDAY EVENINGS

For more information, Circle No. 387

MATERIALS ENGINEERING NEWS

sary for bonding by conventional die or platen hot presses.

In answer to this problem, Narmco Mfg. Co., of La Mesa, Calif., recently installed an autoclave 8 ft in dia by 40 ft long. The new oven will handle the largest bonded structures now being designed for aircraft and missiles.

A vaporizer system is used to provide moisture-free heat to the oven, and temperatures up to 500 F can be controlled with ±5 F. Accessories have been installed for recording actual bondline temperatures from 20 different points within the bonded area during the curing cycle. Maximum pressure obtainable within the oven is 200 psi. Pressures can be automatically controlled within ±3%.

Use of Rubber in Cars Continues to Increase

Cars now use 550 rubber parts, other than tires, adding up to an average of 100 lb per car. And, with the continued emphasis on safety and comfort, use of rubber in the automotive industry is on the increase. According to D. E. Harpfer, assistant manager of industrial products development, Goodyear Tire & Rubber Co., the next logical steps in this use trend are:

1. Springs—A typical air suspension design employs a bellows shape rubber spring that would displace existing metal leaf or metal coil springs. When utilized on cars, rubber springs will provide a better cushioned, level ride and will also permit a lower car silhouette.

2. Gasoline tanks—Rubber gas tanks could be mounted in different locations and thus permit the car stylist to change lines in the rear of the car to improve over-all appearance.

3. Bumpers — Present metal bumpers could be supplemented or replaced with rubber for greater

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PERFORMANCE

ONLY ENAMELSTRIP gives you pre-coated metal coil that has been tested by the United States Testing Company, and *certified* to give quality performance—in your manufacturing operations as well as in the end-use of the finished product!

Tests conducted at the United States Testing Company's laboratories include Scratch Hardness, Salt Spray, Accelerated Weathering, Flexibility, Adhesion, Impact Resistance, Abrasion Resistance, and others.

Enamelstrip pre-coated metal coils are now available in the following:

ORGANIC COATINGS: Alkyds, vinyls, epoxies, phenolics, oleoresinous, and other types of enamels and lacquers.

BASE METALS: Cold rolled steel, tin mill black plate, electrolytic tin plate, electro-galvanized steel, aluminum, brass, copper, and zinc.

VINYL-TO-METAL LAMINATES ALSO AVAILABLE

Vinyl-to-metal laminates, which can be formed, drawn, bent, pierced, blanked, and stamped,—now available in a large variety of colors, embossings, and color prints in as many as 4 colors. Investigate them today!

For further information on Enamelstrip pre-finished coils, call, write, or wire:

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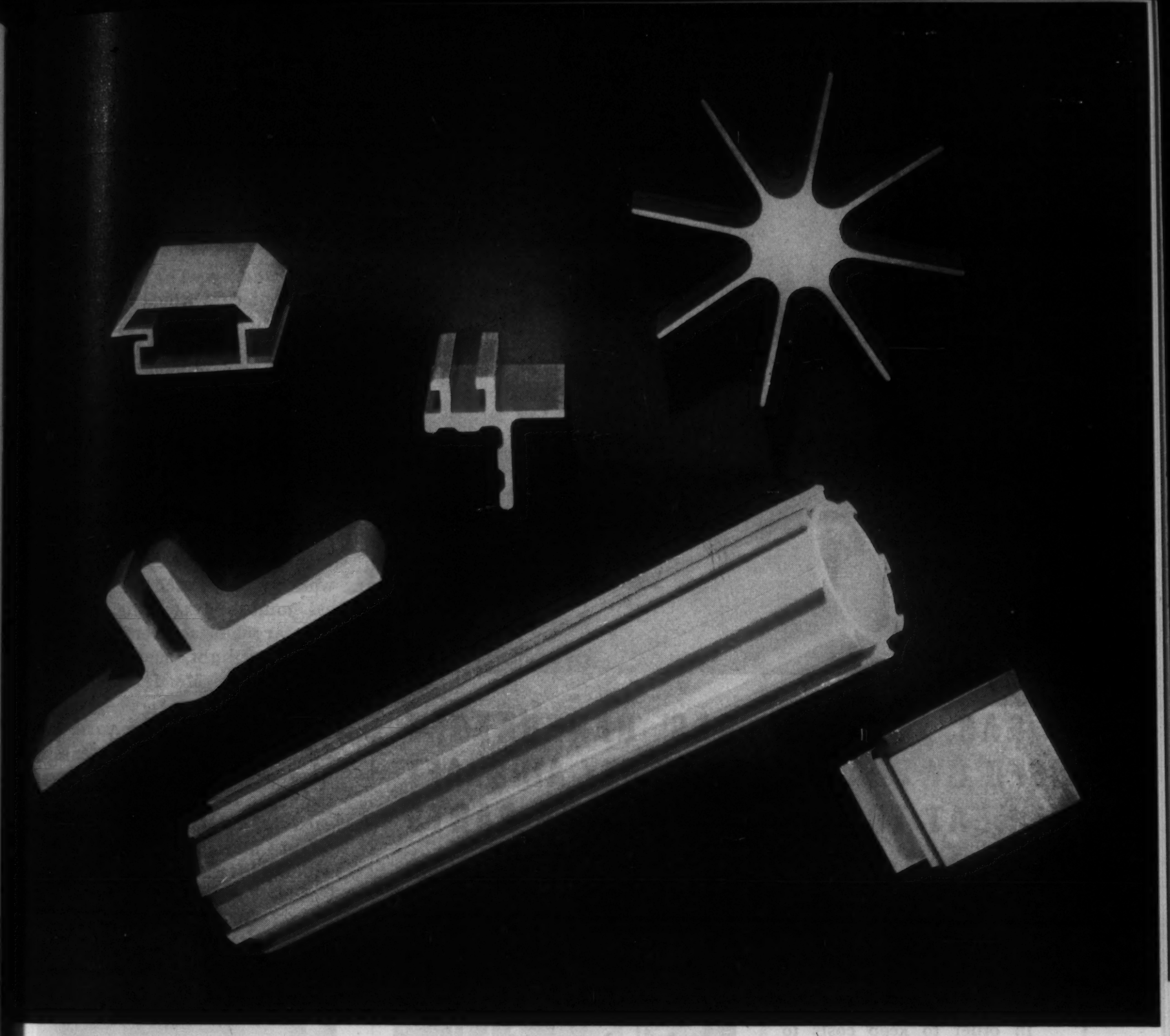

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When you order aluminum extrusions from Michael Flynn, we put our years of metal-working experience to work for you . . . the skill of engineers and metallurgists who know metals and design.

We choose the proper aluminum alloy for the service conditions encountered by your product . . . stresses, strains, temperatures. We study the profile to determine how to achieve maximum strength with a minimum amount of metal.

Every operation, from casting the aluminum billets to final inspection, is under rigid control to maintain quality and keep costs down.

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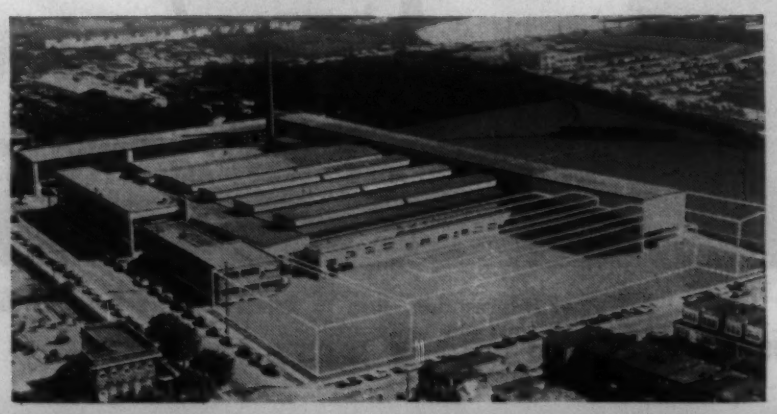
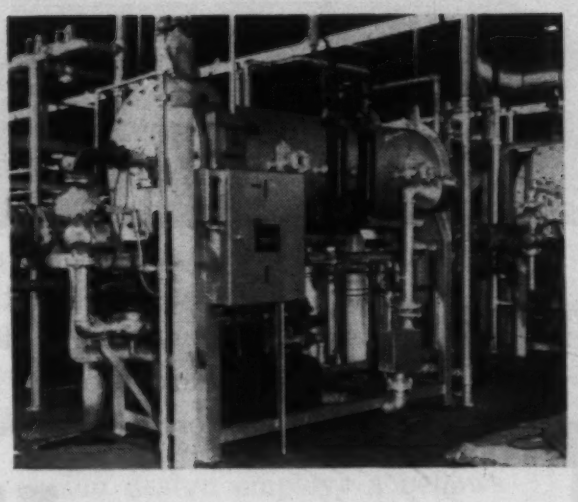


8 GAS ATMOSPHERES' GENERATORS USED BY PRATT and WHITNEY AIRCRAFT IN HEAT TREATING AIRPLANE PARTS

To stress relieve aircraft engine components of both high and low carbon, Pratt and Whitney Aircraft, East Hartford, Conn. uses nitrogen and exothermic gases in their heat treating processes.

In order to keep costs to a minimum, they decided to manufacture their own gases. After thoroughly checking the generation equipment available, they chose a Gas Atmospheres Nitrogen generator and a Gas Atmospheres exothermic generator.



Since that time, they have added to this equipment until today they operate six Gas Atmospheres Nitrogen units of from 3,000 to 6,000 cfh, for heat treating parts of medium high carbon, stainless and alloy steels, and two exothermic generators of 2,000 cfh, for heat treating parts of low carbon steel.

If you use atmospheres in your work, why not poin the ever-increasing list of nationally known manufacturers who agree it pays to make your own gas with Gas Atmospheres equipment.

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equipment for producing industrial gases

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For more information, turn to Reader Service Card, Circle No. 506

MATERIALS ENGINEERING NEWS

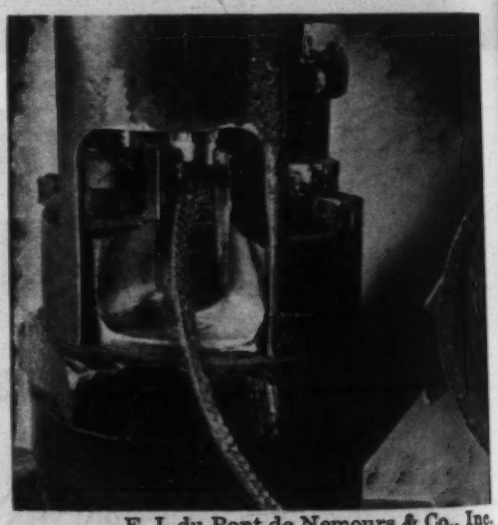
shock absorption in case of a collision.

4. Padding—The present safety factor of cars would be enhanced by use of rubber padding in more places on the inside of the car. Some cars now have this padding on steering wheels and other parts to protect the driver and passengers.

5. Car protection—Rubber can also be used to protect fenders from flying stones and other objects, and similar rubber coverings can be employed to protect working parts such as the universal joint and steering linkages. One car manufacturer has adopted a parking light, made entirely of rubber (see M&M, May '56, p 142).

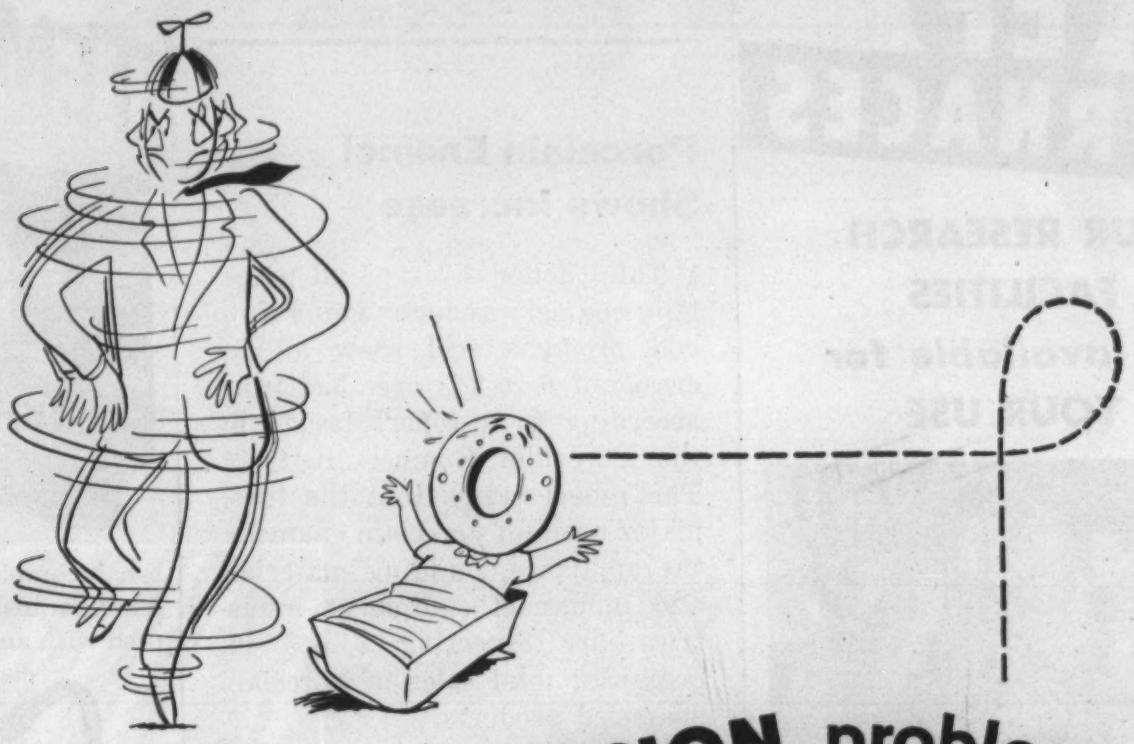
Many of the rubber parts now used in automobiles, Harpfer said, were developed during the past ten years for auxiliary equipment such as automatic transmission, power steering, power brakes, window lifts and air conditioning. Today, 74% of rubber parts in cars are made of synthetic rubber.

(more News on p 240)



E. I. du Pont de Nemours & Co., Inc.

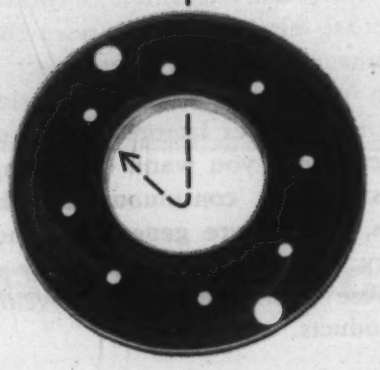
Teflon packing for a chemical processing system handling hydrogen fluoride was still serviceable after 15 weeks. Asbestos packing lasted only three days and required frequent adjustment to prevent leaking. Although Teflon packing cost approximately 10 times more, it lasted 35 times as long, resulting in a favorable cost ratio of 3.5 to 1.



a FRETTING-CORROSION problem had him in a spin

Finding a wear-resistant coating for turbine engine shaft seals posed a serious problem for an aircraft engine manufacturer. Even the hardest alloys were subject to fretting corrosion and had to be replaced after a few hours of service.

This fretting-corrosion problem was solved by having the bearing surface of the seal Flame-Plated by LINDE. By this special detonation process, particles of tungsten carbide are literally *blasted* onto almost any metal surface. Most important, the temperature of the part being plated never exceeds 400° F., so there is little chance that the base metal will warp or that its metallurgical properties will be changed. Flame-Plated tungsten carbide coatings can be applied in thicknesses from .010 to .002 inches. Coatings can be used in the as-coated condition (125 microinches rms) or ground and lapped to a 0.5 microinch finish.



If your design involves metal parts subject to extreme wear, heat, or fretting corrosion, perhaps Flame-Plating can eliminate some or all of your "headaches"—or make possible some completely new idea.

To find out, write us about your wear problem or request a free copy of LINDE's booklet, "Flame-Plating," F8065. Address Flame-Plating Department.

Flame-Plating *by* Linde

LINDE AIR PRODUCTS COMPANY

A Division of Union Carbide and Carbon Corporation

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For more information, turn to Reader Service Card, Circle No. 511

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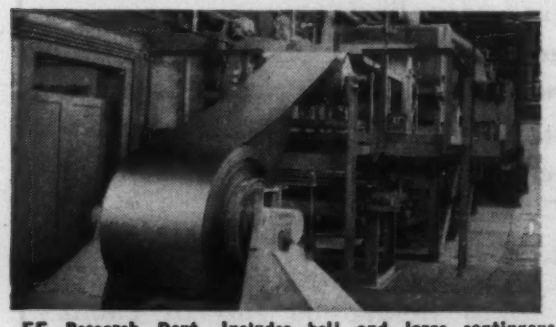
OUR RESEARCH FACILITIES *are available for* YOUR USE

General view of the research department showing several of the continuous and batch type experimental furnaces.

Let us help you develop new heat treating techniques or improve your present methods. Determine accurately—from actual test runs in our research and development laboratory—the exact combination of temperature, time cycle, atmosphere and other factors for producing the exact results you want. Our complete facilities include continuous and batch furnaces, atmosphere generators, and all necessary testing equipment. Many companies use our facilities in developing new products.

Write today for the booklet "Research Facilities". It describes the equipment we can place at *your* disposal.



EF Research Dept. includes bell and large continuous units for testing and processing commercial widths of strip from standard coils.

BULLETIN No. 461
shows typical installations of EF Gas-fired, Oil-fired and Electric Furnaces
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MATERIALS ENGINEERING NEWS

Porcelain Enamel Shows Increase

Total dollar sales of all porcelain enamel products going into end products will show an increase of 6 to 7% over last year, according to a report issued by the Porcelain Enamel Institute. The report states that the three major users of porcelain enamel—the appliance, building materials and industrial equipment industries—are expecting a 6% increase in total sales of porcelain enameled products.

Household appliance manufacturers, who account for more than 50% of porcelain enamel volume, will expand output by 4%, and recent surveys made by one of the leading frit manufacturers are claimed to show a five to three consumer preference for porcelain enamel exteriors on refrigerators, washers and dryers.

The building materials industry, which includes architectural porcelain enamel, plumbing fixtures, signs and hot water tanks, has shown the largest increase in use of porcelain enamel and anticipates as much as a 20% increase this year.

Second Lecture Series On Titanium Scheduled

The second annual titanium lecture program designed specially for practicing engineers will be conducted at New York University College of Engineering Sep 10 through 14.

Titanium authorities from industry and research laboratories, together with members of the NYU faculty, will present 25 lectures. The roster of speakers includes two leading British authorities on titanium, Allan D. McQuillan, of the University of Birmingham, and his wife, Marian McQuillan, of Imperial Chemical Industries.

Subjects to be covered are: Sep

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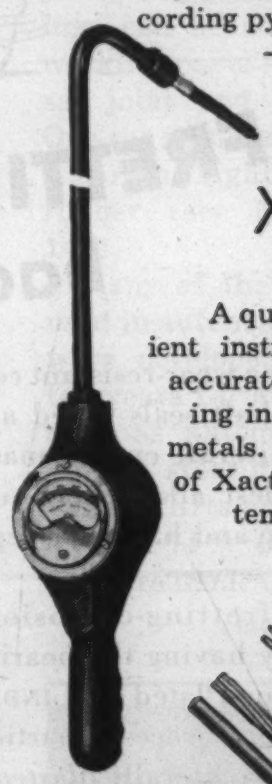
Controls temperature automatically within a fraction of a degree in any heat process. A complete factory-assembled unit ready for installation anywhere. Can be used with any existing indicating or recording pyrometer controller —regardless of age.



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Hand Pyrometer

A quality-built, convenient instrument for quick, accurate temperature reading in molten nonferrous metals. Also, other models of Xactemp for all-around temperature checking.

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Thermocouple Wire
Thermocouple Extension Wire

Insulated in Gordon's own plant to assure consistent quality.
All standard wire and insulations carried in stock for quick delivery.
Other wires, in long or short runs, manufactured to specifications.

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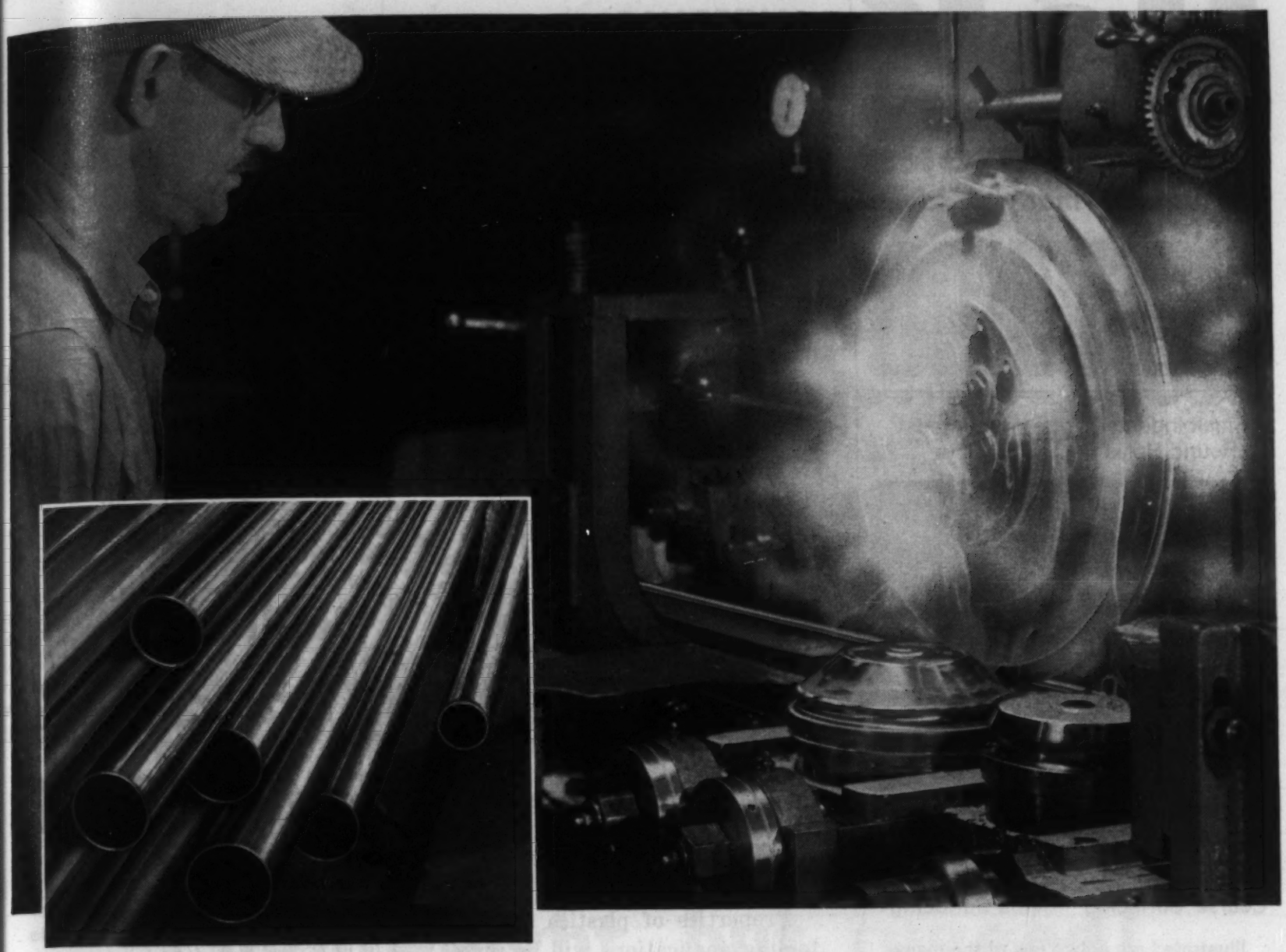

IN ELECTRIC-WELD PIPE AND TUBE MAKING

Yoder leads the way

to higher speeds and quality at lower cost

In the short period from 1938 to 1955, the production of electric welded pipe and tubing grew from 269,000 tons to over 3,000,000 tons. This phenomenal rate of growth—over two and one-half times faster than that of the pipe and tube making industry as a whole—to a large extent resulted from a series of important improvements in tube mill design, all introduced by Yoder.

First came the Yoder rotating welding transformer, in 1938. The economic and other benefits conferred by this epoch making innovation were further augmented by other technological advances scored by Yoder in the years that followed. The result was that electric-weld pipe and tube making became the child prodigy of the fast growing pipe and tube making industry.

Latest, and perhaps the greatest, of these developments is the cold forming and induction welding at high speeds of *aluminum, magnesium, brass, nickel, monel, and other non-ferrous metals and alloys.* This process is especially economical for making light and medium gauge tubes in sizes up to 8 in. dia. More and more leading non-ferrous metal producers and fabricators are installing these mills.

More complete information about this and other interesting Yoder developments in pipe and tube mill equipment may be had merely by asking for any of the following publications:

- ☐ Resistance-Weld Mills for making Steel Tubing up to 4" diameter.
- ☐ Induction-Weld Mills for making Non-ferrous Tubing.
- ☐ Resistance-Weld Mills for Steel Pipe up to 24" diameter.

THE YODER COMPANY

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ENGINEERING YODER MANUFACTURING

PIPE AND TUBE MILLS—Electric Weld

ROTARY SLITTING LINES

COLD ROLL FORMING MACHINES

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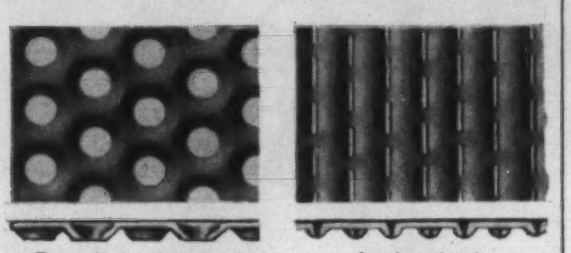

Small Indented Round Holes

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1/16" Triangular Stabbed Holes

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Illustrated are only a few of the many surfaced perforations for which we have dies. We have thousands of different die patterns to perforate practically any metal in sheets, rolls and coils.

If your product requires surfaced perforated materials, contact either H & K office or one of our agents. We will be glad to work with you on your perforating requirements.

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THE **Harrington & King** PERFORATING CO.

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- ☐ GENERAL CATALOG NO. 62
- ☐ STOCK LIST of Perforated Steel Sheets
- ☐ SAMPLES of Perforated Plastics and Paper
- ☐ PRICE INFORMATION (NOTE: Send specifications of perforated materials wanted. If necessary send drawings or sketches.)

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CITY_____ ZONE_____ STATE_____

For more information, Circle No. 466

MATERIALS ENGINEERING NEWS

10, extraction and melting; Sep 11, phase diagram metallography and alloying; Sep 12, heat treatment and mechanical properties; Sep 13, mechanical metallurgy and applications; Sep 14, fabrication. Evening discussion sessions will supplement the lectures, which will be given at the University Heights campus in the Bronx.

Attendance at the NYU lecture program will be limited. Applicants may register until Aug 15. Further information and applications can be obtained from Harold Margolin, New York University College of Engineering, University Heights 53, N. Y.

Plastics Tooling Research Project

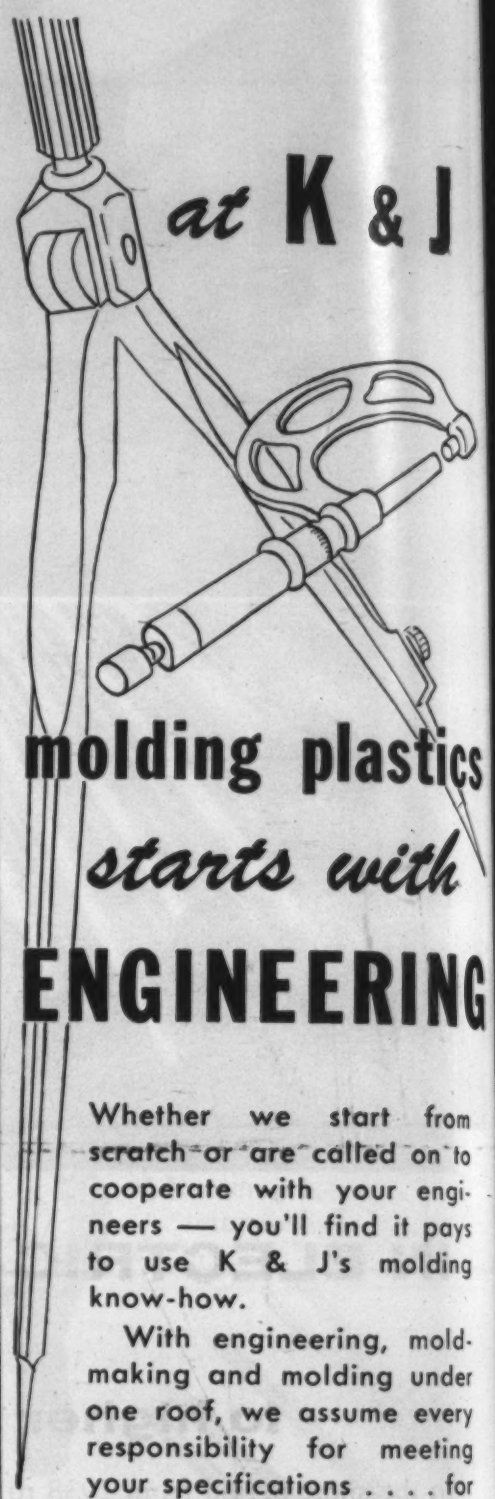
Properties of plastics used for tooling applications will be investigated by Purdue Research Foundation. Initiated by the American Society of Tool Engineers Research Fund, the study will concentrate on the following:

1. A survey of existing literature and visits to plants for background on tested engineering data.

2. Establishment of standard

U. S. Steel Corp.

Spring fatigue is tested on this machine. The machine can test two springs at one time, each with a compression as high as 7500 lb, at speeds up to 1500 cycles per min. Railroad coupling springs are shown here.



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Whether we start from scratch or are called on to cooperate with your engineers — you'll find it pays to use K & J's molding know-how.

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Injection mold — extrude — calender.

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MARBON CHEMICAL . . . *Precision Resins for Precision Made Products*

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Westlake
ULTRA-ETHYLUX
The New, Special Service Super-Polyethylene

- 4 times greater rigidity
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Test samples, preliminary data and technical service supplied in response to your detailed inquiries.

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In Lower Delaware Valley, U.S.A.
New Phone No.: MEdia 6-5170

For more information, Circle No. 493

test methods for measuring and predicting: shrinkage characteristics; abrasion resistance; heat resistance; and physical properties essential in plastics for tooling in stamping and forming operations.

Additional studies will also be made to determine the specific results that may be expected when any one of these variables is altered. The ultimate findings will then be compiled into a basic manual for engineers involved in plastics tooling.

New Markets Expand Stainless Steel Use

Stainless steel is rapidly becoming accepted as one of the most versatile materials available. Key to increased acceptance is its unique range of dependable properties. Republic Steel Corp., which recently increased its stainless steel making facilities by 18%, announced that stainless steel will find increasing use in aircraft and atomic energy plants.

Aircraft use

Fifty percent or more of tomorrow's supersonic planes will utilize stainless steel in their construction, according to Republic Steel. Numbered among the virtues of stainless are its ability to resist corrosion and heat and still maintain strength, and its ability

Electrical Contact Materials

Coming in September

A 20-page report on how to select the right material for an electrical contact. Prepared by a leading contact manufacturer, it tells how to first evaluate the operating conditions and service requirements, then choose the basic contact composition and design.

Graph-i-tite

SOLVES CORROSION AND HIGH TEMPERATURE PROBLEMS

Graph-i-tite . . .

is a carbon-impregnated graphite material of construction, which can be formed into cylinders, tubes, nozzles, crucibles, molds, and special shapes. It is used to contain fluid flow in reactors, for piping, nozzles and processing equipment used in production of chlorine, chlorinated metals, molten salts, and in other corrosive or high temperature chemical and metallurgical processes. GRAPH-I-TITE may also be used for crucibles for transistor crystal growth, as rocket nozzle inserts, as well as a power reactor moderator.

Graph-i-tite . . .

possesses exceptional heat transfer characteristics, and is unaffected by most corrosives. It is impermeable, immune to thermal shock, non-wettable, non-contaminating, will not absorb radiation, and withstands operating temperatures up to 5700° F.

In addition, custom formulated graphite (impregnated or untreated) can be supplied with specified purity, density or other properties for special applications. Extrusion, molding and machining facilities are available for limited or high production work.

Write today about your specific problems. CATALOG AVAILABLE.

GRAPHITE SPECIALTIES CORP.
64th STREET AND PINE AVENUE
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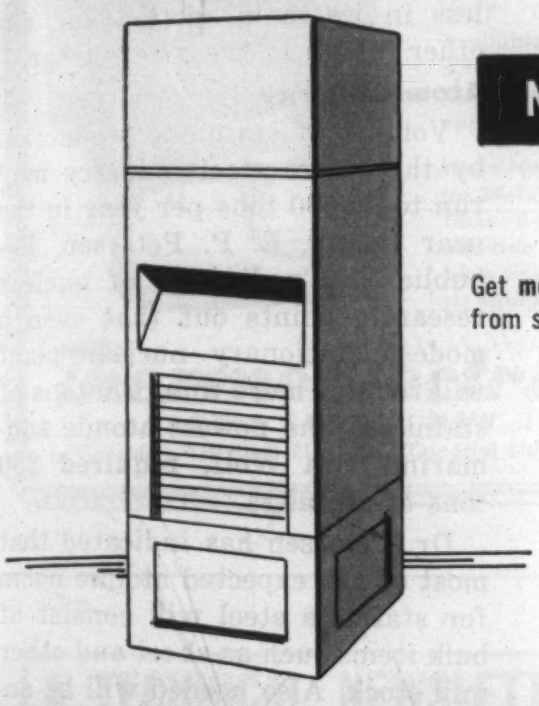
under new A.G.A. approval requirements for gas-fired heating equipment . . .

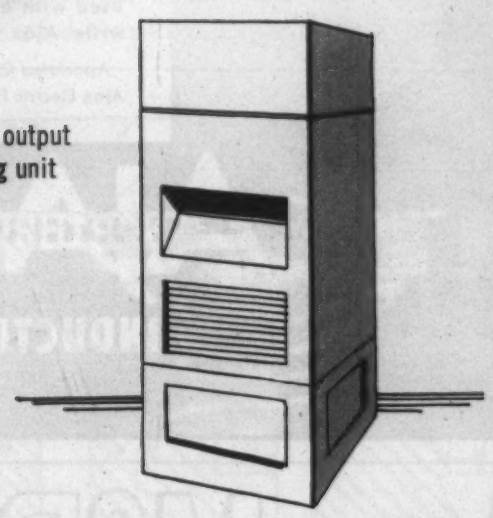
You can gain cost-saving advantages with Armco ALUMINIZED STEEL



Now with ALUMINIZED STEEL

Get **more** BTU output from same size unit

Get present BTU output from **space-saving** unit



New A.G.A. approval requirements permit use of hot-dip aluminum coated steel at operating temperatures up to 1030°F, plus room temperature, in heating elements of gas-fired heating equipment. This is an increase of 225°F over the old maximum.

These new approval requirements open the door to manufacturers who want to take full advantage of the heat- and corrosion-resisting properties of Armco ALUMINIZED STEEL Type 1. If you make gas-fired heating units, here's what this special aluminum coated steel offers you:

- **more BTU's from same size unit**
- **same BTU's from smaller unit**
- **space-saving units to meet modern trend**
- **lower cost than for any other heat-resisting material permitted at comparable temperatures**

HERE'S WHY:

Independent tests show that Armco ALUMINIZED STEEL stands up longer than any metal in its price class under cyclic high temperature heating and cooling in the presence of either sulfur-free or sulfur-bearing gases. Years of use by manufacturers of heating equipment back up these tests.

If you make appliances that require resistance to heat and corrosion consider Armco ALUMINIZED STEEL Type 1. Just write us at the address below for full information about this Armco Special Steel.

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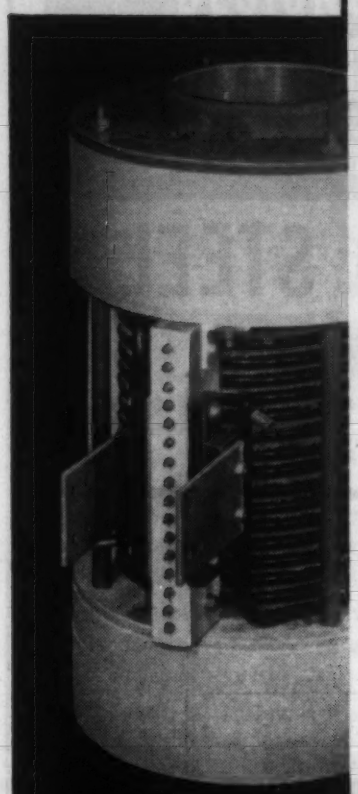


High Temperature Furnaces

FOR CARBIDES, HOT PRESSING AND GRAPHITIZATION

Whether you manufacture carbides on a production line basis, or conduct high temperature studies in the laboratory, Ajax-Northrup equipment provides the ideal answer for your heating requirements. Fast efficient heat . . . at temperatures from 1200° to 2600°C and above . . . with negligible heat loss to surroundings . . . are all advantages that only Ajax-Northrup high temperature furnaces afford.

Ajax provides a variety of special furnaces for carbide manufacture and high temperature research. Essentially these are skeleton type furnaces operated by motor generators or high-frequency converters.

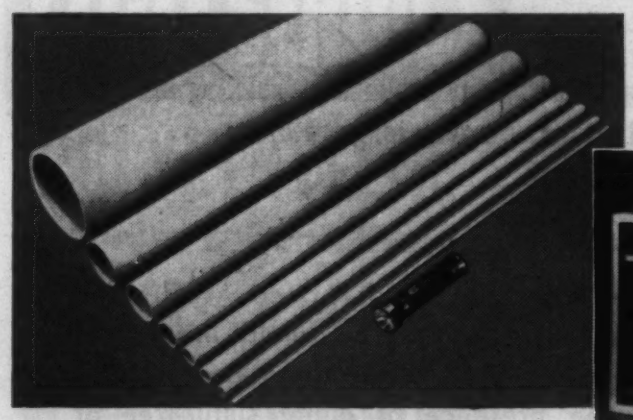
Carbide furnaces are usually equipped with Acheson graphite crucibles or sleeves which are good conductors of electricity and capable of attaining high temperatures. For hot pressing of carbides, either graphite or oxide refractory sleeves are employed and the furnaces may be used with either vertical or horizontal presses. For details, write Ajax Electrothermic Corp., Trenton 5, New Jersey.

Associated Companies: Ajax Electric Company—Ajax Electric Furnace Co.—Ajax Engineering Corp.

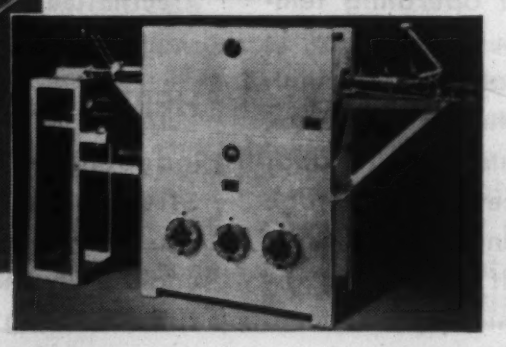
AJAX NORTHRUP SINCE 1916

INDUCTION HEATING-MELTING

→McDANEL←



Furnace below equipped with McDanel Zirco Tube, 46" long, 1½" I.D., 1¾" O.D. Operates at temperatures from 1,650 to 3,000° F. Name of manufacturer on request.



Protection Tubes Help Produce Controlled Atmosphere at 3,000° F. In Research Electric Furnace

Sintering, brazing and other heat-treating experiments are conducted in this laboratory furnace applied to research. It uses a McDanel Zirco Protection Tube, open at both ends. Sample heats and cools in gas-tight tube, permitting use of many special atmospheres. McDanel Protection Tubes have high resistance to thermal shock—low coefficient of expansion. Special sizes! Write now! *Send for Bulletin P1-55.*

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REFRACTORY PORCELAIN COMPANY

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MATERIALS ENGINEERING NEWS

to take a smooth surface finish important in minimizing skin friction.

The supersonic plane of tomorrow will be rocketed along by jet units that in themselves contain 50% or more of stainless steel. One jet engine now in production has better than 1000 lb of stainless in its main section and another 600 lb in the afterburner.

Atomic energy

Volume of stainless production by the entire steel industry may run to 20,000 tons per year in the near future. R. P. Petersen, Republic Steel's director of nuclear research, points out that even a modest stationary nuclear plant will require more than 100 tons of stainless. The newest atomic submarine, Sea Wolf, required 300 tons of stainless.

Dr. Petersen has indicated that most of the expected atomic boom for stainless steel will consist of bulk items such as sheet and other mill stock. Also needed will be accessory stainless products such as nuts, bolts, washers and tubing.

ASTM Annual Meeting Sets Attendance Mark

More than 2800 members of the American Society for Testing Materials registered for the 59th Annual Meeting held at Atlantic City in June. This attendance fig-

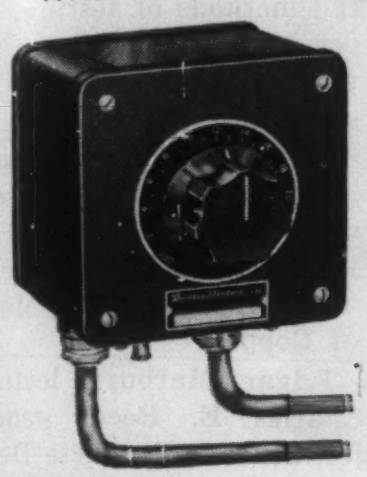
Which Polyethylene?

Coming in September

Ordinary physical and mechanical property data have only limited usefulness in the selection of plastics for specific uses. By explaining the relationship between certain measurable molecular characteristics of polyethylenes and their end properties, this article provides a more realistic basis for making the proper choice.

MODERNIZE
YOUR THERMOCOUPLE CIRCUITS
WITH T-E ROTARY
SELECTOR SWITCHES

These new switches are designed to enable the user to switch rapidly from one thermocouple circuit to another . . . can be used with all types of millivoltmeter- or potentiometer-type pyrometers, and with resistance thermometers. Stocked in 3 sizes: "OFF" to 6 point, "OFF" to 12 point and "OFF" to 24 point. Available in several different forms and housings to suit your application.

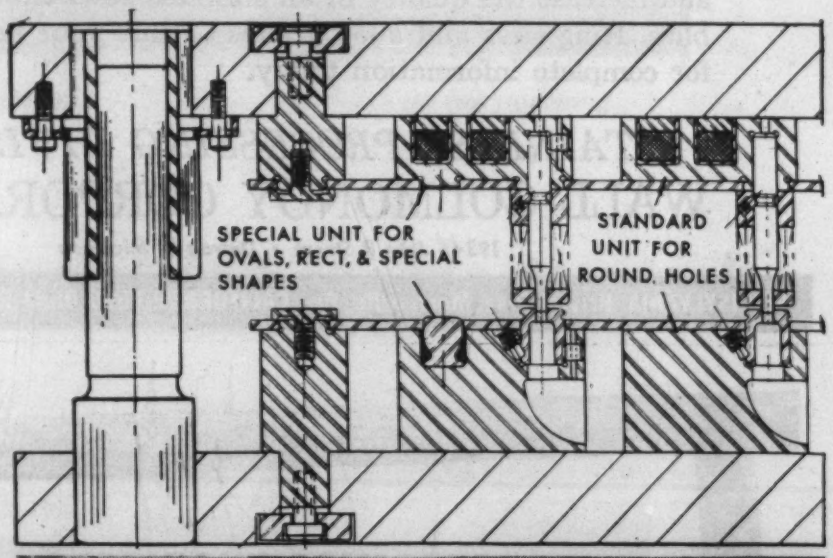


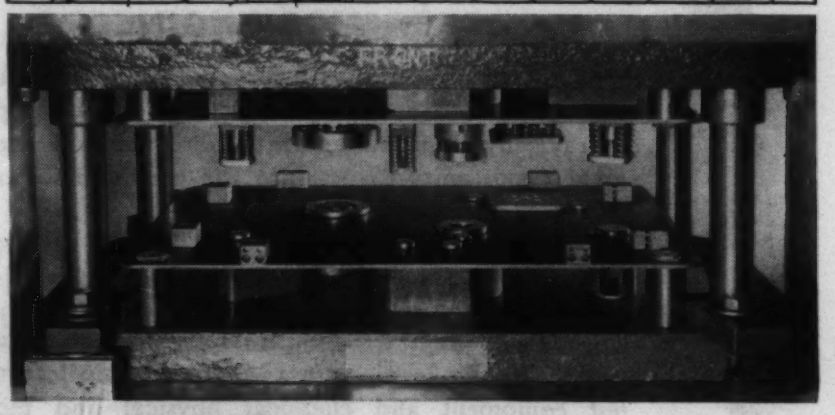
Write today for Bulletin 24-100 and quotations on this latest addition to our complete line of pyrometric equipment.

Thermo Electric Co., Inc.
SADDLE BROOK, NEW JERSEY
In Canada—THERMO ELECTRIC (Canada) Ltd., Brampton, Ont.

MAGNETIC DIES by WHISTLER

• Operate like a single-purpose die • All punch and die parts interchangeable • Pierce metals up to ¼" thick steel • Changes made from one operation to another while the die set is in the press • Change-over time from 5 to 20 minutes, depending upon size of die set • Lower die costs • Saves die storage space • Precision work in any size press • Backed by Whistler's 40 years of die making experience serving the nation's leading plants.





YOU NEED THIS CATALOG . . . Shows by photos, drawings and prices how the Magnetic Die* system drastically cuts die costs, saves valuable time, speeds production. *Write for it today.*

**Whistler Magnetic Dies are fully patented and are sold under the copyrighted trade name Magna-Die.*

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ADJUSTABLE, MAGNETIC and CUSTOM DIES FOR ALL INDUSTRY
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Every issue features a technical article on the use of MOLYKOTE Lubricants in industry • "How-to" stories on tough lubrication applications • Filled with engineering data which applies to all industries • Being published regularly.

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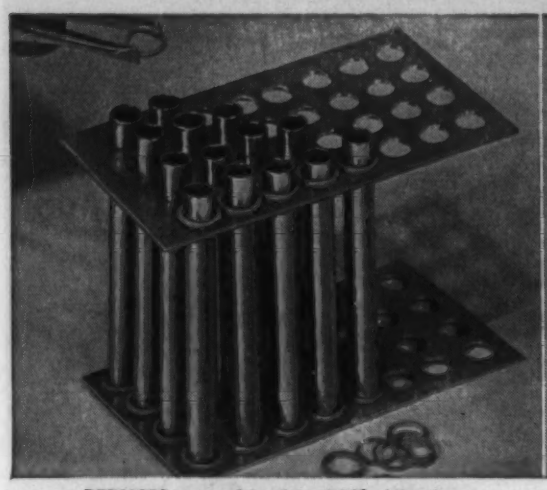
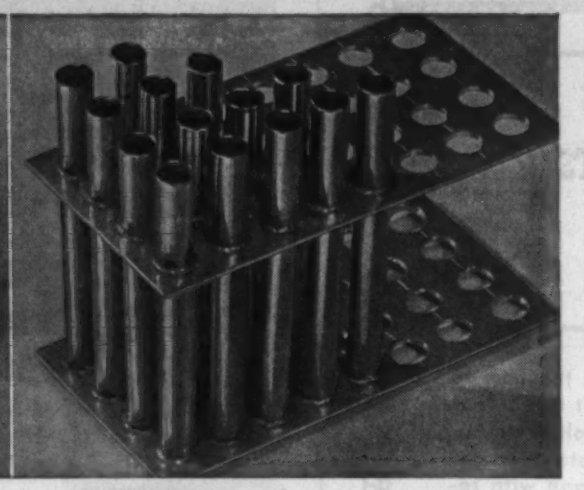


REDUCES assembly time 85%. Nicrobraz rings are simply slipped over tube ends.



ELIMINATES material waste and rejects. Rings produce perfect joints every time.

Speed Stainless Tube Assembly with Prefabricated Brazing Rings

Nicrobraz, the stainless steel brazing alloy, is now available as prefabricated brazing rings. They'll speed the fabrication and increase the quality of all stainless steel tubular assemblies. Ring sizes and alloy grades to suit your needs. Write for complete information today.

STAINLESS PROCESSING DIVISION
WALL COLMONOY CORPORATION
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PENNSYLVANIA: Bristol Pike, Morrisville, Pa., CALIFORNIA: 1565 Bluff Road, Montebello, Cal.

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MATERIALS RESEARCH

To evaluate high temperature resistant non-metallic materials for use in aircraft and guided missiles; to devise test equipment and chemical physical and mechanical tests to furnish design information for the use of cermets, glass, and ceramic materials for structures, thermal shields, transparencies, dielectrics, adhesives, coatings for protection against oxidation, corrosion, erosion, and radiation to investigate the potentials of processes to best utilize these materials in the manufacture of airframes and missiles.

Please send complete resume including details of your technical background to:

Mr. David G. Reid
Engineering Personnel Mgr.

REPUBLIC AVIATION
FARMINGDALE, LONG ISLAND, NEW YORK

MATERIALS ENGINEERING NEWS

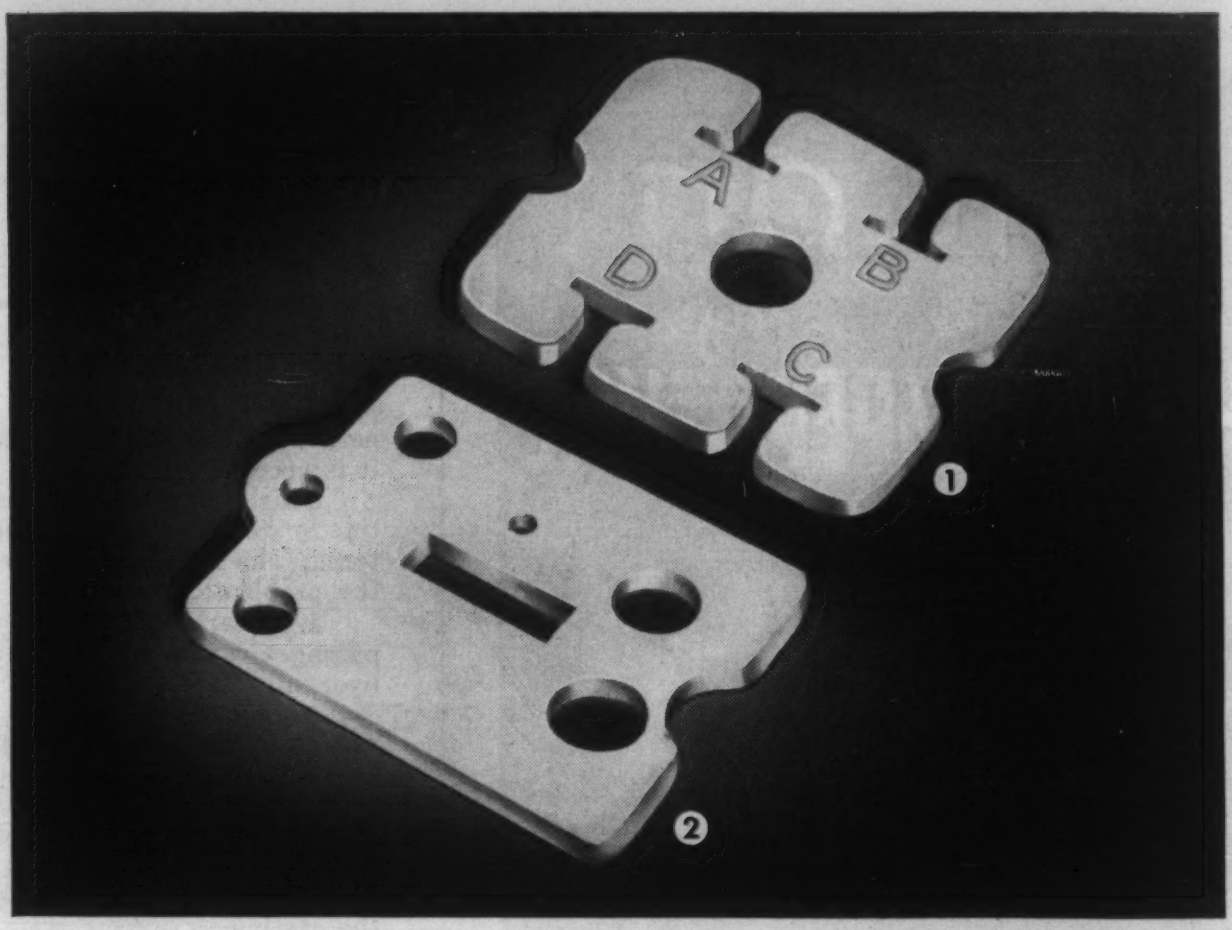
ure topped all previous records and testified to industry's growing interest in promoting the knowledge of engineering materials by standardizing specifications and methods of testing.

Copper and silicones were the subjects of the two memorial lectures sponsored by ASTM. D. K. Crampton, director of research and development, Chase Brass & Copper Co., Inc., presented the fifth Gillett Memorial Lecture on "Structural Chemistry and Metallurgy of Copper."

The Edgar Marburg lecturer was Charles E. Reed, general manager, Silicone Products Dept., General Electric Co. In his talk entitled "The Industrial Chemistry, Properties and Applications of Silicones," Dr. Reed discussed the basic chemical structure of silicones and their use in the electrical, aircraft, protective coating and textile industries.

New officers of ASTM are listed on p 228.

Load cell measuring 3 in. high by 3 in. dia was specially designed for high mechanical frequency response by selecting tungsten carbide for the bases. Tungsten carbide reduced deflection under load to one-third that of steel components, maximum deflection under a capacity 20,000-lb load being only 0.0005 in. The result is a natural frequency response of about 1900 cps—more than twice that of any previous unit. This SR-4 load cell was developed by Baldwin-Lima-Hamilton Corp. to measure high frequency variations of thrust imparted by explosive reactions of solid propellant rockets.



1. Grade XP-240 for warm punching. *2. Grade XXP-241 for hot punching.*

Put these two new Taylor phenol laminates to work

HERE are two major additions to the extensive Taylor line of laminated plastics. There's a good chance that a product you're now designing can be improved through the use of these new materials . . . or that products now in your production line can be more economically made with them. Check the features of these outstanding paper base, phenolic laminates. They may be exactly what you're looking for.

Grade XP-240 is a warm punching grade that requires some heat when punching more complicated shapes, though much less heat than comparable NEMA grades . . . and can be cold punched in thicknesses to 1/16". With this material, there's no lifting around punched holes, and check-in is negligible. It has excellent staking characteristics, and good dielectric strength. XP-240 has much to recommend it for such applications as insulating washers, terminal boards, plug and socket bases, switch bases, panels for sub-assemblies, and terminal strips.

Grade XXP-241 is a hot punching grade with excellent physical and electrical characteristics, plus good moisture-resisting properties. It's dimensionally stable, punches without lifting around holes, and machines with clean-cut edges. XXP-241 can be used to advantage in such applications as condenser stator brackets, wave switch rotors and stators, plug and socket bases, terminal boards and sub panels, insulating washers. Both laminates are available in sheets approximately 49" x 49".

If you're interested in fitting these tough, versatile materials into your plans, Taylor engineers will help you work out design and production details. Call or write for the facts.

TAYLOR FIBRE CO. • Plants in Norristown, Pa. and La Verne, Calif.

Taylor Fabricating Facilities

Your production can be simplified . . . schedules safeguarded . . . inventory headaches cured . . . and over-all costs reduced by having Taylor fabricate finished parts to your specifications. Efficient, modern facilities are ready to serve you. Get in touch with Taylor about your specific requirements.

TAYLOR
Laminated Plastics
Vulcanized Fibre

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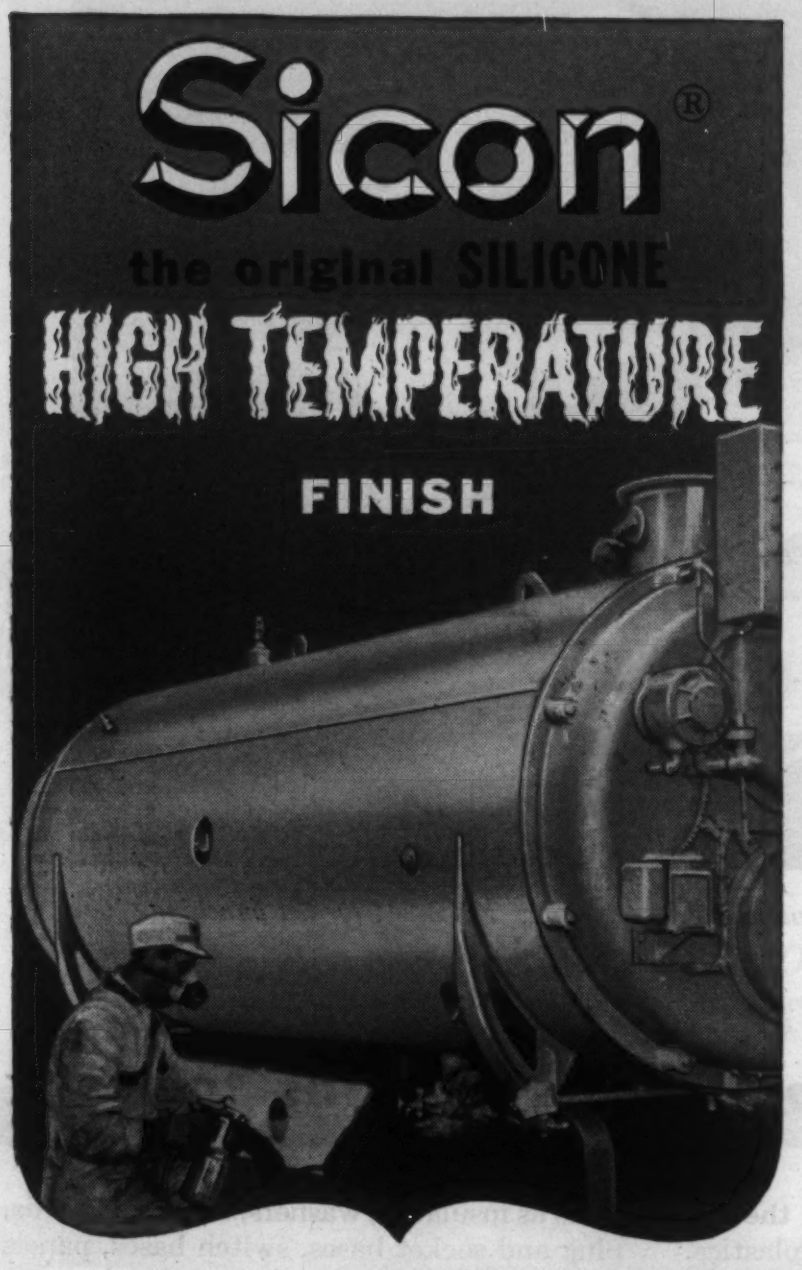

chosen for CLEAVER-BROOKS "CB" line of packaged boilers

SICON has reduced finishing costs for Cleaver-Brooks and provided a longer lasting finish that retains its color and gloss at temperatures in the range of 500° F., far above the hottest skin temperatures normally encountered.

Sparkling SICON Gray and SICON Maroon identify the "CB" line. One coat sprayed on is all that is required. It air-dries fast and maintains its attractive colors and protective qualities for the life of the unit.

For a silicone heat resistant finish that has stood the test of heat and time, write for the *complete* SICON story! Dept. H-1.

RETAINS COLOR AND GLOSS

FAST DRYING

EASY TO APPLY

SICON® *is manufactured exclusively by*

MIDLAND *Industrial Finishes Co.*
EAST WATER ST., WAUKEGAN, ILLINOIS
ENAMELS SYNTHETICS LACQUERS VARNISHES

For more information, turn to Reader Service Card, Circle No. 436

LETTERS TO THE EDITOR

continued from p 14

peratures (600 F) that are now being encountered, it is necessary for us to go to stainless steel.

This change in material presents many difficulties in coring that have not heretofore been encountered. The following list will give you some idea of the problem:

1. Interior coring is a must. The drilling of passages causes turbulence and pressure drop of the hydraulic fluid.

2. As the coring will be used is a casting of 420 stainless, the melting point of which is 2700 F, the coring must withstand this temperature with little or no deforming during casting.

3. Complete removal of the core must be accomplished by chemical means (removal of the core by mechanical means is impossible) without damaging the casting.

We are interested in rod sizes from 1/16 in. to 1/2 in. dia and in special shapes with total dimensions up to 3 x 3 x 4 in.

J. N. HAW
Aeronautical Div.
Minneapolis-Honeywell Regulator Co.
Minneapolis, Minn.

We can't be of much help on this problem, but maybe there are some coring experts in the audience.

Makes box, must fillet

To the Editor:

We would appreciate your assistance in locating a source for a material that could be used for creating fillets in corners and along edges of fabricated steel box ware.

This material, if available, must be inexpensive, simple to apply, have exceptional adhesive strength and be able to withstand temperatures of 350 to 400 F for periods of 1/2 hr or longer. It must also accept white bake enamel finishes without discoloring.

E. B. SPERRY, Project Engineer
Thomas Industries, Inc.
Fort Atkinson, Wis.

The first materials that come to mind are the various epoxy and metal-filled epoxy resin compounds, but they are not low in cost. Any other suggestions?

A foreign car, maybe

To the Editor:

We are positive that GM, Ford and Chrysler, as well as Link belt, will be intrigued with the timing gear sprocket illustrated on p 137 of your May '56 issue.

HERBERT M. WHITE
Dept. of Highways
State of Ohio
Bowling Green, Ohio

We are also intrigued. The editor responsible for shuffling the photographs still can't explain how he mistook a garage hoist for a timing gear sprocket.